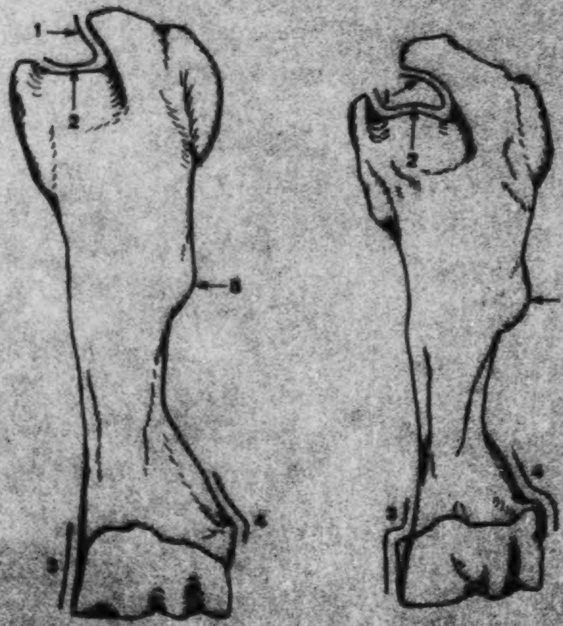
Syllogeus 71

A Guide to the Identification of Postcranial Bones of *Bos taurus* and *Bison bison*

Darlene McCuaig Balkwill
and Stephen L. Cumbaa



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Canadian Museum of Nature
Musée canadien de la nature
Syllogeus No. 71

Ottawa 1992

93-00639/

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Published by the:

Canadian Museum of Nature
Ottawa, Canada K1P 6P4

Catalogue No. NM95-20/71E

Available by mail order from:

Canadian Museum of Nature
Direct Mail Section
P.O. Box 3443, Station "D"
Ottawa, Canada K1P 6P4

Syllogeus Series No. 71
Printed in Canada
ISBN: 0-660-13066-1
ISSN: 0704-576X

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Publié par le :

Musée canadien de la nature
Ottawa, Canada K1P 6P4

N° de catalogue NM95-20/71E

L'éditeur remplet les commandes postales
adressées au :

Musée canadien de la nature
Section des commandes postales
C.P. 3443, succursale D
Ottawa, Canada K1P 6P4

Serie Syllogeus N° 71
Imprimé au Canada
ISBN : 0-660-13066-1
ISSN : 0704-576X

Text pages printed on paper
containing recycled fibre.

Les pages du texte sont imprimés
sur un papier contenant
des fibres recyclés.

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ACKNOWLEDGEMENTS

We owe a large debt of gratitude to Robert Balkwill for his assistance with all of the statistical aspects of this study, for his tremendous patience in trying to explain to us how to apply the beautiful logic of mathematics to the sometimes inexact attributes of faunal comparative data. We would also like to gratefully acknowledge the following individuals and institutions for providng ready access to their comparative specimens: staff of the Mammalogy departments of the Royal Ontario Museum and the Smithsonian Institution; Dr. Howard Savage, Faunal Osteology Laboratory, Department of Anthropology, University of Toronto; and Curatorial Assistants David Campbell of the Mammalogy Section and Gerald Fitzgerald of the Palaeobiology Division of the Canadian Museum of Nature. Our appreciation is also extended to the Canadian Parks Service for the opportunity to study the Fort Walsh faunal material, and to Anne Rick, then Head of the Zooarchaeological Identification Centre, for her support and encouragement at the beginning of this study. Numerous faunal analysts, archaeologists and palaeontologists urged us to publish this study, and we are grateful for their encouragement. We would like to particularly thank Richard E. Morlan, Jonathan C. Driver and Howard Savage, each of whom took time from extremely busy schedules to critically read and provide helpful comments on a draft of this monograph.

INTRODUCTION

The impetus for this study of the postcranial skeletal characteristics of cattle, *Bos taurus*, and bison, *Bison bison*, was the examination by the Zooarchaeological Identification Centre, Canadian Museum of Nature, of several thousand well-preserved bones from a late 19th century archaeological site in the Cypress Hills of southwestern Saskatchewan. The zooarchaeological material recovered from Fort Walsh, a Northwest Mounted Police post, included all parts of the bovid skeleton, and accurate identification of the material was necessary for conclusions regarding the food supply of the men occupying the fort. During the 1870's the earliest cattle ranches were opening up in western Canada as the last of the large bison herds were hunted, and both the wild and domestic bovids were regular table fare. Since the bones of the two species are so similar, identification necessarily involved the use of several comparative skeletons of each genus in addition to constant reference to Olsen's (1960) standard work on the subject. However, after the analysis was underway it became apparent that, because of the nature of the archaeological specimens, we had to attempt to go further than Olsen had gone in his study; for instance, roughly 60% of the bovid bones from Fort Walsh were ribs and vertebrae, which were either not included or not given full treatment in Olsen's monograph. In addition, the smaller tarsals and all of the carpals were omitted from Olsen's work. The greater density and the resultant higher survivability rate of these small elements makes them an important component of many faunal assemblages.

Other difficulties, to which Olsen (1960) and Lawrence (1951) refer, centred on the fact that for many of the bones, no single character existed which allowed absolute separation of the two species. We realized that after at least two relatively intense North American comparative studies, there was little likelihood that any new absolutely separable characters would be found. Instead, we decided to take Olsen's characters (taken from Lawrence, other workers, and his own observations), add to them our own, and score each character of each element by checking its validity against as large a series of known comparative skeletons of each species as possible. In this way, we have been able to weight each character; in effect saying "character X of element Y proved useful in separating the two species in 18 of 20 cases, or 90% of the specimens examined". We hope that this will improve upon such vague qualifiers as "most of the specimens", "generally", "there is a tendency", etc.

Lawrence (1951:37) examined 10 *Bos* skeletons of several breeds as well as the skeletons of 12 *Bison*. Olsen (1960:6) included observations on an undesignated number of *Bos taurus*, representing 6 breeds, 18 *Bison bison* skeletons, and 9 skeletons of the zebu, *Bos indicus*. We have not examined or discussed the latter species in any way. Our own observations are based on 16 skeletons of *Bos taurus*, representing at least 5 breeds (Holstein, Ayrshire, Shorthorn, Longhorn, and Africander), and 27 skeletons of *Bison bison*, including individuals of both the *bison* and *athabascae* subspecies. The identification, location, and pertinent biological data of the specimens we examined are presented in Appendix 3.

A total of 192 characters have been described and rated; those marked with an asterisk were described by Olsen (1960). Olsen's inclusion of *Bos indicus* led us to paraphrase rather than directly quote his character descriptions; however, we have retained his terminology and tampered as little as possible with his wording. All of Olsen's characters have been included in this study, with the exception of his two characters for the thoracic vertebrae. Here Olsen has described characteristics specific to individual vertebrae (viz. the second thoracic and the eighth thoracic), whereas our approach has been to subdivide the thoracics into three regions and deal with characters that are more broadly applicable, in recognition of the difficulty in picking out individual thoracic vertebrae.

The simple illustrations were drawn by the authors using a Goodkin Indirect Drawing Viewer Model 5B, which, like a camera lucida, allows tracing of bone outlines and features. These drawings, coupled with the descriptions of the characters and ready access to at least one adult specimen of each of the two species should be clear enough to illustrate the distinguishing characteristics. Format of the plates follows the "field guide style", with the characters marked on the drawings and the appropriate character description on the facing page. Elements are described in the sequence of vertebral column and ribs, front limb, hind limb. In the case of paired elements, the left side is illustrated throughout.

Osteological terminology is a continuing problem in studies such as the present one, as there is no universally accepted set of standard terms for anatomical elements and orientation. Originally we had decided to follow von den Driesch (1976) for all directional nomenclature, but comments from some of our colleagues convinced us that using "cranial" and "caudal" can be confusing in some cases. While these two terms work well when referring to bones of the axial skeleton, their meaning is much less clear for limb elements. Rather than compound the confusion by using a dual terminology system for orientation (i.e. "anterior" and "posterior" for the appendicular skeleton, but "cranial" and "caudal" for the axial skeleton), we decided to use the terms "anterior" and "posterior" throughout. Our application of these terms to limb elements is done under the assumption that the animal is in a standing position. For anatomical nomenclature we have followed that in Sisson and Grossman (1975).

Some characteristics were much more useful than others in distinguishing the two species. Immediately following the description of each character is a two-tiered table which provides a quantitative assessment of that character's reliability and usefulness. The upper tier gives the "success rate", a measure which, expressed as a percentage, indicates the number of cases in which the specimen exhibited the "correct" aspect of the character as described for that species. The success rates have been listed separately for each species; we found that often a character would have a high success rate for one species but not for the other, which limits its usefulness. The bottom tier is more detailed; it shows the number of specimens that agreed with a particular aspect of the character, the number that disagreed, and the number that fell into the "grey area" in between. In addition, this portion of the table gives a "preference factor" rating for each character, obtained through applying maximum likelihood theory. The preference factor provides a convenient shorthand way of expressing the probability that a given element, exhibiting a given character, belongs to *Bison* and, independently, the probability that it belongs to *Bos*. The application of maximum likelihood theory to this study is described in detail in Appendix 1.

Perhaps the most useful feature of this comparative study is its assessment of the utility of individual or grouped characters for the identification to species of a given element, rather than the list of characters *per se*. By scoring the "success" of each character on each reference specimen in our sample, and thus highlighting the most "reliable" characters, we hope to give the users of this guide a greater confidence in the results of their identifications. We also add a statistical approach which uses probability theory to evaluate the maximum likelihood that a given element under consideration is *Bos* or that it is *Bison*.

CAUTIONARY NOTES

1). We began with slightly over 200 characters, but winnowed out those that we found too vague to describe or score consistently. However, we retained all but two (as noted above) of the characteristics described by Olsen (1960), although several proved unreliable in our study. We have also retained several characters of our own that looked good early in the study but which ultimately proved too variable to be useful in distinguishing the two species.

Such characters can be quite misleading if only a few comparative specimens are checked, and we have included them here to demonstrate the difficulties inter-specific morphological variation presents to the comparative osteologist, and the value of large sample sizes. Because this study includes characters that proved useful and reliable, as well as those with low or ambiguous success rates, IT IS VITAL THAT NO CHARACTER BE CONSIDERED IN ISOLATION FROM ITS SUCCESS RATE AND/OR ITS PREFERENCE FACTOR RATING.

2). Please note that these characters apply only to distinguishing *Bos taurus* and *Bison bison*; we have not made any attempt to test the characters on other species within these genera.

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DESCRIPTION OF CHARACTERS

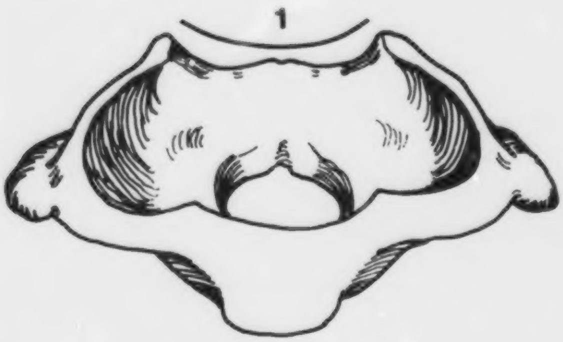
CERVICAL VERTEBRAE - ATLAS

Fig. 1. Anterior View

(1) The floor and sides of the ventral margin of the anterior notch in *Bison* form a smooth curve. In *Bos* the sides rise more abruptly from the floor, with a distinct break in the curve.

success rate for *Bison*	20/24 = 83.33%
success rate for *Bos*	9/11 = 81.82%

Character #1: anterior notch, ventral margin	Aspect 1	Aspect 2	Aspect 3
	smooth curve	break in curve	intermediate
No. of *Bison*	20/24	3/24	1/24
No. of *Bos*	0/11	9/11	2/11
Preference Factor *Bison*	26.15	0.17	0.28
Preference Factor *Bos*	0.04	5.80	3.60



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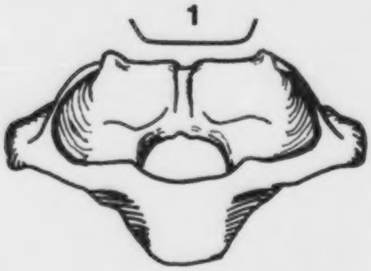

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Figure 1. Atlas, Anterior View

CERVICAL VERTEBRAE - ATLAS

Fig. 2. Ventral View

(2)* The wings of the atlas in *Bison* form a square outline at their terminus, while those of *Bos taurus* have a tendency to be pointed.

success rate for *Bison*	16/24 = 66.67%
success rate for *Bos*	9/11 = 81.82%

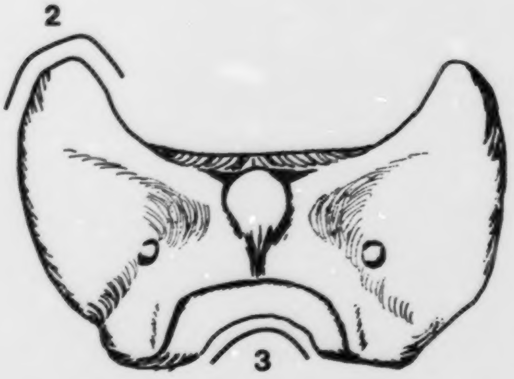
Character #2: terminus of wings	Aspect 1	Aspect 2	Aspect 3
	squared	pointed	intermediate
No. of *Bison*	16/24	2/24	6/24
No. of *Bos*	2/11	9/11	0/11
Preference Factor *Bison*	3.12	0.12	8.28
Preference Factor *Bos*	0.32	8.15	0.12

(3)* The dorsal margin of the anterior notch viewed ventrally is curved or cup-shaped in *Bison* and squared-off in *Bos*.

success rate for *Bison*	17/25 = 68.00%
success rate for *Bos*	11/12 = 91.67%

Character #3: dorsal margin of anterior notch	Aspect 1	Aspect 2	Aspect 3
	curved	squared	intermediate
No. of *Bison*	17/25	5/25	3/25
No. of *Bos*	1/12	11/12	0/12
Preference Factor *Bison*	5.83	0.23	4.65
Preference Factor *Bos*	0.17	4.27	0.22

* this and any subsequent characters indicated with an asterisk are from Olsen (1960)



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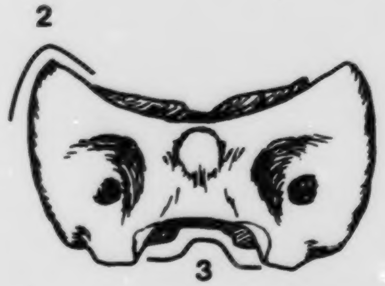

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Figure 2. Atlas, Ventral View

CERVICAL VERTEBRAE - ATLAS

Not Illustrated:

(4)* The shape of the vertebral foramen when viewed anteriorly approaches a triangle in *Bison*; in *Bos* it is more rounded or oval.

success rate for *Bison*	11/25 = 44.00%
success rate for *Bos*	7/12 = 58.33%

Character #4: shape of vertebral foramen	Aspect 1	Aspect 2	Aspect 3
	triangular	rounded or oval	intermediate
No. of *Bison*	11/25	7/25	7/25
No. of *Bos*	4/12	7/12	1/12
Preference Factor *Bison*	1.25	0.49	2.50
Preference Factor *Bos*	0.80	2.04	0.40

CERVICAL VERTEBRAE - AXIS

Fig. 3. Lateral View

(1)* The dorsal margin of the dens in *Bison* slopes at an acute angle. In *Bos* this same margin has a definite break, giving a stepped appearance.

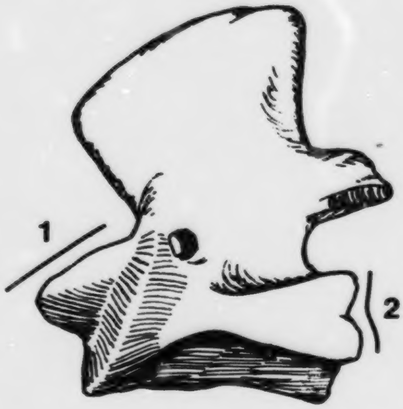
success rate for *Bison*	23/24 = 95.83%
success rate for *Bos*	14/14 = 100.0%

Character #1: shape of dens	Aspect 1	Aspect 2	Aspect 3
	diagonal	squared	intermediate
No. of *Bison*	23/24	0/24	1/24
No. of *Bos*	0/14	14/14	0/14
Preference Factor *Bison*	37.80	0.02	2.37
Preference Factor *Bos*	0.03	66.59	0.42

(2) The transverse process shows a slight bifurcation at the posterior end in *Bison*, but not in *Bos*.

success rate for *Bison*	22/24 = 91.67%
success rate for *Bos*	12/12 = 100.0%

Character #2: transverse process	Aspect 1	Aspect 2	Aspect 3
	bifurcation	no bifurcation	intermediate
No. of *Bison*	22/24	2/24	0/24
No. of *Bos*	0/12	12/12	0/12
Preference Factor *Bison*	31.20	0.10	0.51
Preference Factor *Bos*	0.03	9.87	1.96



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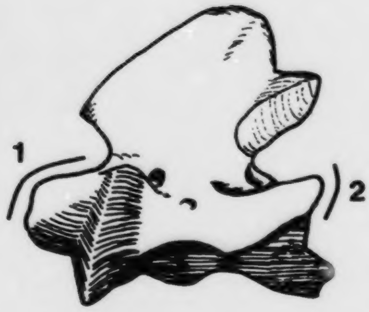

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Figure 3. Axis, Lateral View

CERVICAL VERTEBRAE - AXIS

Fig. 3. Lateral View

(3) The foramen at the posterior end of transverse canal is not visible in *Bison* when viewed laterally. In *Bos* it is visible, just anterior to the posterior end of the vertebral foramen.

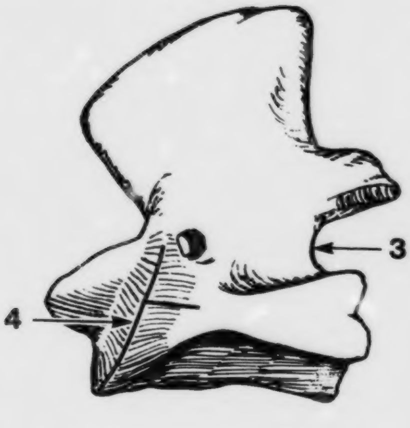
success rate for *Bison*	21/25 = 84.00%
success rate for *Bos*	9/13 = 69.23%

Character #3: transverse foramen	Aspect 1 not visible	Aspect 2 visible	Aspect 3 intermediate
No. of *Bison*	21/25	2/25	2/25
No. of *Bos*	3/13	9/13	1/13
Preference Factor *Bison*	3.26	0.14	0.89
Preference Factor *Bos*	0.31	7.22	1.12

(4)* The lateral margin of the anterior articular process is almost perpendicular to the long axis of the body in *Bos*, but at a more obtuse angle in *Bison*.

success rate for *Bison*	19/22 = 86.36%
success rate for *Bos*	4/8 = 50.00%

Character #4: anterior articular process	Aspect 1 obtuse angle	Aspect 2 perpendicular	Aspect 3 intermediate
No. of *Bison*	19/22	0/22	3/22
No. of *Bos*	3/8	4/8	1/8
Preference Factor *Bison*	2.11	0.03	0.90
Preference Factor *Bos*	0.47	32.33	1.12



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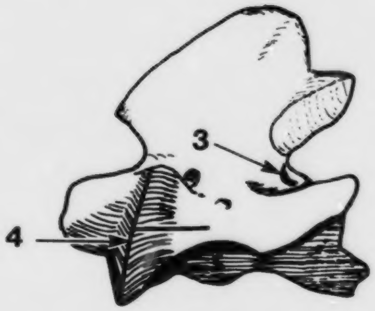

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Figure 3. Axis, Lateral View

CERVICAL VERTEBRAE - AXIS

Fig. 3. Lateral View

(5) The transverse process is angled upwards in *Bos*, almost parallel to the long axis of the body in *Bison*.

success rate for *Bison*	22/22 = 100.0%
success rate for *Bos*	**6/8 = 75.00%

Character #5: transverse process	Aspect 1	Aspect 2	Aspect 3
	parallel	angled up	intermediate
No. of *Bison*	22/22	0/22	0/22
No. of *Bos*	2/8	6/8	0/8
Preference Factor *Bison*	3.42	0.02	0.38
Preference Factor *Bos*	0.29	46.75	2.65

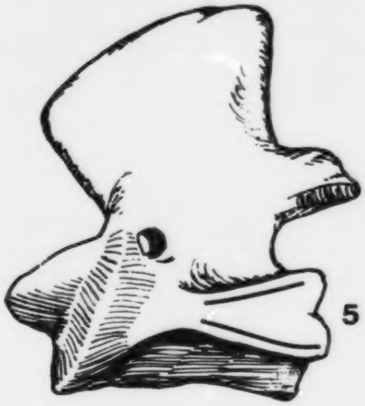
(6)* In old *Bison* bulls the anterior tip of the spinous process directly overhangs the forward tip of the dens. (Not illustrated)

success rate for *Bison*	3/11 = 27.27%
success rate for *Bos*	**6/6 = 100.00%

Character #6: spinous process	Aspect 1	Aspect 2	Aspect 3
	present	absent	intermediate
No. of *Bison****	3/11	8/11	0/11
No. of *Bos*	0/6	6/6	0/6
Preference Factor *Bison*	5.36	0.74	0.56
Preference Factor *Bos*	0.19	1.35	1.77

** Note that *Bos* sample sizes are very small.

*** Only adult male Bison were scored for this character.



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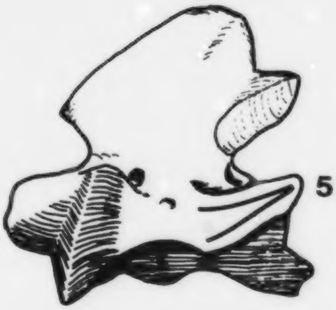

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Figure 3. Axis, Lateral View

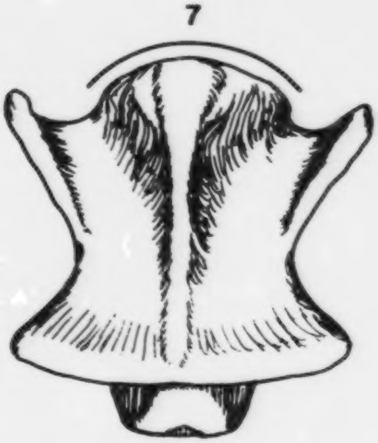
CERVICAL VERTEBRAE - AXIS

Fig. 4. Ventral View

(7) The ventral edge or lip of the posterior articular margin is rounded in *Bison*, more pointed in *Bos*.

success rate for *Bison*	21/22 = 95.45%
success rate for *Bos*	14/14 = 100.0%

Character #7: shape of ventral edge	Aspect 1	Aspect 2	Aspect 3
	rounded	pointed	intermediate
No. of *Bison*	21/22	1/22	0/22
No. of *Bos*	0/14	14/14	0/14
Preference Factor *Bison*	37.66	0.07	0.64
Preference Factor *Bos*	0.03	15.29	1.55



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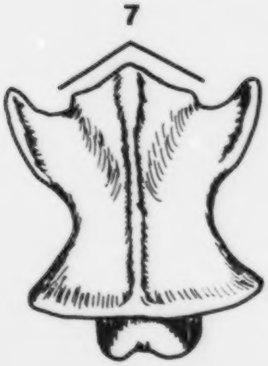

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Figure 4. Axis, Ventral View

THIRD - SEVENTH CERVICAL VERTEBRAE

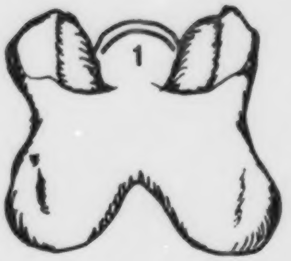
Fig. 5. Dorsal View

The following four distinctions are especially noticeable for the third, fourth and fifth cervicals, less so for the sixth and seventh cervicals.

(1) The lateral margins of the head of the centrum are nearly parallel in *Bos*, whereas in *Bison* they expand outward as they approach the body, making the head appear broader in *Bison*.

success rate for *Bison*	21/22 = 95.45%
success rate for *Bos*	7/12 = 58.33%

Character #1: lateral margins of head of centrum	Aspect 1	Aspect 2	Aspect 3
	expand outward	nearly parallel	intermediate
No. of *Bison*	21/22	0/22	1/22
No. of *Bos*	5/12	7/12	0/12
Preference Factor *Bison*	2.17	0.03	2.22
Preference Factor *Bos*	0.46	36.68	0.45



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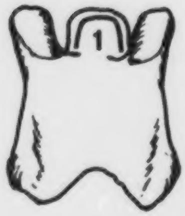

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Figure 5. Cervical 3, Dorsal View (neural spine removed)

THIRD - SEVENTH CERVICAL VERTEBRAE

Fig. 5. Dorsal View

(2) The lateral margins between the anterior and posterior articular processes are strongly indented in *Bison*, much less so in *Bos*.

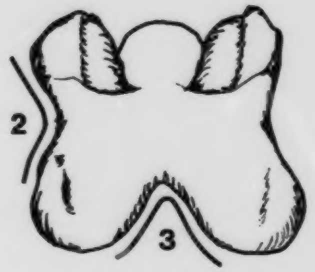
success rate for *Bison*	21/25 = 84.00%
success rate for *Bos*	14/14 = 100.0%

Character #2: lateral margins	Aspect 1	Aspect 2	Aspect 3
	strongly indented	less indented	intermediate
No. of *Bison*	21/25	1/25	3/25
No. of *Bos*	0/14	14/14	0/14
Preference Factor *Bison*	33.22	0.06	5.39
Preference Factor *Bos*	0.03	17.33	0.19

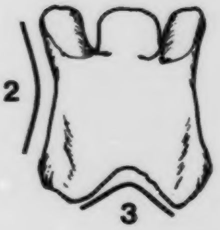
(3) The posterior margin of the neural arch in *Bison* has a deep narrow constriction between the posterior articular processes. This constriction in *Bos* is wider and shallower.

success rate for *Bison*	25/25 = 100.0%
success rate for *Bos*	9/14 = 64.29%

Character #3: posterior margin of neural arch	Aspect 1	Aspect 2	Aspect 3
	deep & narrow	wide & shallow	intermediate
No. of *Bison*	25/25	0/25	0/25
No. of *Bos*	4/14	9/14	1/14
Preference Factor *Bison*	3.23	0.02	0.14
Preference Factor *Bos*	0.31	45.40	7.04



BISON



BOS

Figure 5. Cervical 3, Dorsal View (neural spine removed)

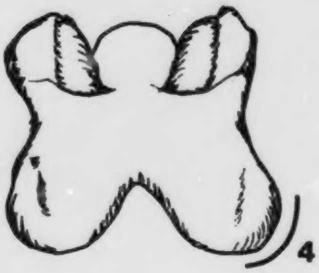
THIRD - SEVENTH CERVICAL VERTEBRAE

Fig. 5. Dorsal View

(4) The margin of the posterior articular process is rounded in *Bison*, straighter in *Bos*.

success rate for *Bison*	15/24 = 62.50%
success rate for *Bos*	8/11 = 72.73%

Character #4: margin of posterior articular process	Aspect 1	Aspect 2	Aspect 3
	rounded	straighter	intermediate
No. of *Bison*	15/24	3/24	6/24
No. of *Bos*	2/11	8/11	1/11
Preference Factor *Bison*	2.93	0.19	2.07
Preference Factor *Bos*	0.34	5.19	0.48



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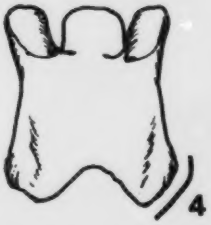


BOS

Figure 5. Cervical 3, Dorsal View (neural spine removed)

CERVICAL VERTEBRAE

Fig. 6. Anterior View

(5) The shape of the head of the centrum differs in the two genera. In *Bos* the sides of the head are neatly tucked in or pinched, so that the head seems narrow and the foramina are not obscured. In *Bison* the head is wider at the top and appears to partially obscure the transverse foramina, especially in C.3 and C.4. (Not marked on illustration)

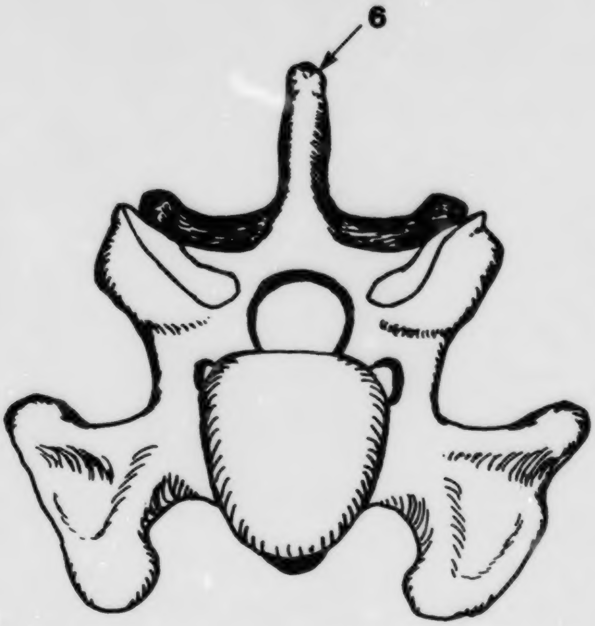
success rate for *Bison*	20/23 = 86.96%
success rate for *Bos*	11/12 = 91.67%

Character #5: anterior view of head	Aspect 1	Aspect 2	Aspect 3
	narrow	wider	intermediate
No. of *Bison*	20/23	2/23	1/23
No. of *Bos*	1/12	11/12	0/12
Preference Factor *Bison*	7.41	0.11	2.13
Preference Factor *Bos*	0.13	8.71	0.47

(6)* The dorsal end of the neural spine is more expanded in *Bos* than in *Bison* in C.3-C.5.

success rate for *Bison*	21/23 = 91.30%
success rate for *Bos*	11/12 = 91.67%

Character #6: dorsal end of neural spine	Aspect 1	Aspect 2	Aspect 3
	less expanded	more expanded	intermediate
No. of *Bison*	21/23	1/23	1/23
No. of *Bos*	0/12	11/12	1/12
Preference Factor *Bison*	31.08	0.07	0.53
Preference Factor *Bos*	0.03	14.69	1.88



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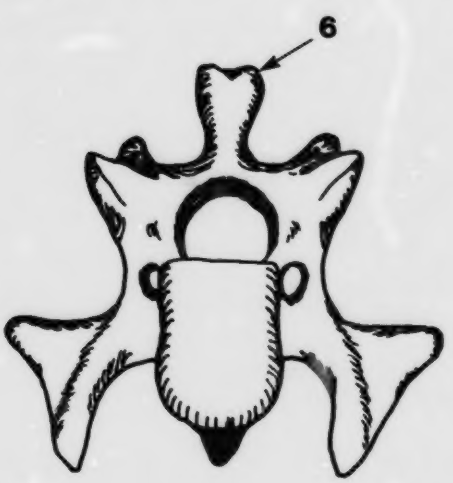


BOS

Figure 6. Cervical 3, Anterior View

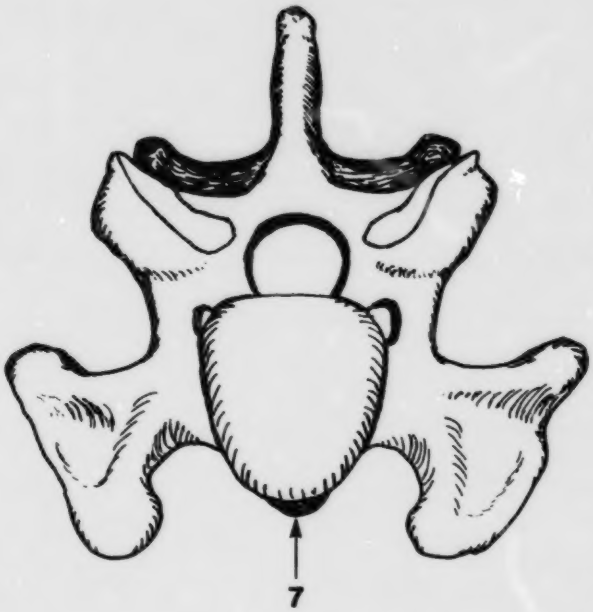
CERVICAL VERTEBRAE

Fig. 6. Anterior View

(7) There is a very noticeable postero-ventral projection of the centrum in *Bos*, especially in the third and fourth cervicals. The projection is much less noticeable in *Bison*.

success rate for *Bison*	25/25 = 100.0%
success rate for *Bos*	13/14 = 92.86%

Character #7: posteroventral projection	Aspect 1 absent	Aspect 2 present	Aspect 3 intermediate
No. of *Bison*	25/25	0/25	0/25
No. of *Bos*	0/14	13/14	1/14
Preference Factor *Bison*	39.41	0.02	0.14
Preference Factor *Bos*	0.03	64.53	7.04



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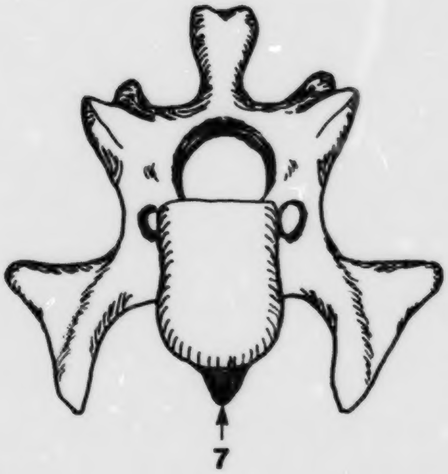


BOS

Figure 6. Cervical 3, Anterior View

CERVICAL 3

Fig. 7. Lateral View

(8) The posterior end of the transverse foramen of the third cervical vertebra is anterior to the posterior end of the centrum in *Bos*, and the opening is visible in lateral view. In *Bison* this opening is found either inside the vertebral arch or even with the posterior end of this arch, and cannot be seen in this view.

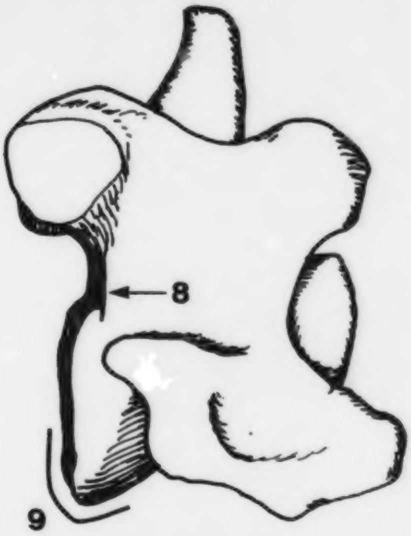
success rate for *Bison*	21/25 = 84.00%
success rate for *Bos*	13/13 = 100.0%

Character #8: posterior end of transverse foramen	Aspect 1	Aspect 2	Aspect 3
	not visible	visible	intermediate
No. of *Bison*	21/25	2/25	2/25
No. of *Bos*	0/13	13/13	0/13
Preference Factor *Bison*	30.93	0.10	3.57
Preference Factor *Bos*	0.03	10.27	0.28

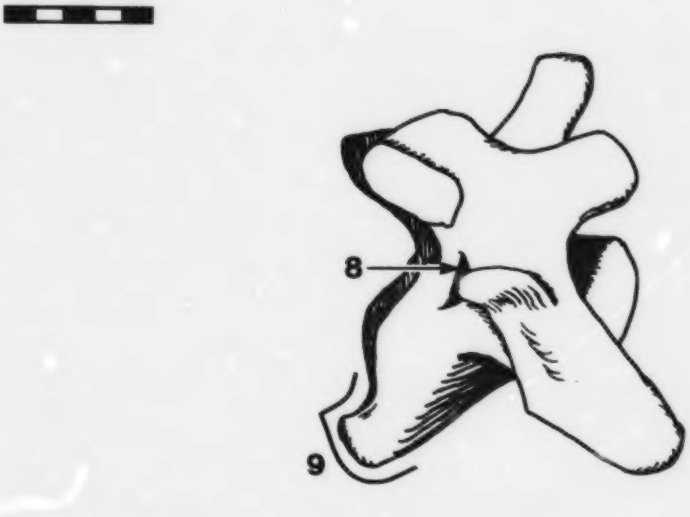
(9) *Bos* has a ventral projection at the posterior end of the centrum; *Bison* does not.

success rate for *Bison*	25/25 = 100.0%
success rate for *Bos*	13/13 = 100.0%

Character #9: posteroventral projection	Aspect 1	Aspect 2	Aspect 3
	absent	present	intermediate
No. of *Bison*	25/25	0/25	0/25
No. of *Bos*	0/13	13/13	0/13
Preference Factor *Bison*	36.69	0.01	0.53
Preference Factor *Bos*	0.03	69.31	1.89



BISON



BOS

Figure 7. Cervical 3, Lateral View

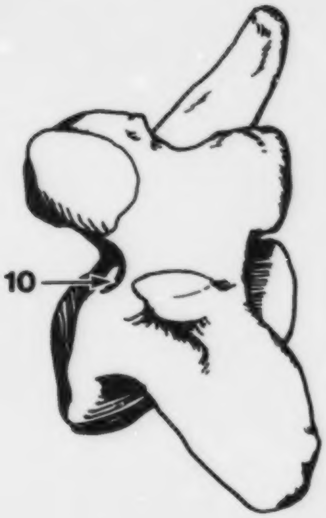
CERVICAL 4

Fig. 8. Lateral View

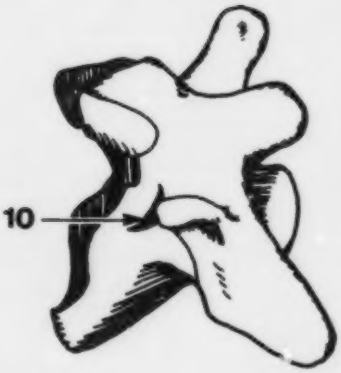
(10) In both *Bos* and *Bison* fourth cervicals the transverse foramen ends anterior to the posterior end of the vertebral arch, but only slightly so in *Bison* and to a much greater extent in *Bos*.

success rate for *Bison*	17/24 = 70.83%
success rate for *Bos*	13/14 = 92.86%

Character #10: transverse foramen end	Aspect 1	Aspect 2	Aspect 3
	less anterior	more anterior	intermediate
No. of *Bison*	17/24	5/24	2/24
No. of *Bos*	0/14	13/14	1/14
Preference Factor *Bison*	28.15	0.24	1.00
Preference Factor *Bos*	0.04	4.15	1.00



BISON



BOS

Figure 8. Cervical 4, Lateral View

CERVICAL 5

Fig. 9. Posterior View

(11)* The C.5 outline formed by the tips of the anterior articular processes and the ventral branches of the transverse processes is rectangular in *Bison* and more squarish in *Bos*.

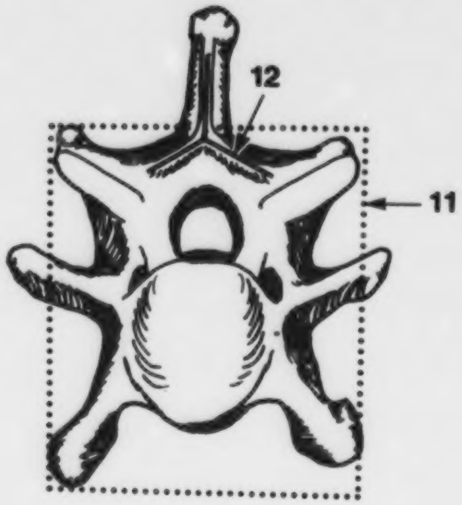
success rate for *Bison*	5/20 = 25.00%
success rate for *Bos*	2/11 = 18.18%

Character #11: shape of outline	Aspect 1	Aspect 2	Aspect 3
	rectangular	squarish	intermediate
No. of *Bison*	5/20	13/20	2/20
No. of *Bos*	9/11	2/11	0/11
Preference Factor *Bison*	0.32	3.05	3.79
Preference Factor *Bos*	3.08	0.33	0.26

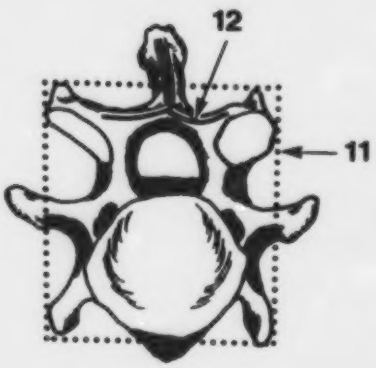
(12) The ridge from the neural spine divides higher up in *Bison* than in *Bos*. The branches come off almost horizontally in *Bos*, and there is a plateau at the posterior base of the neural spine. In *Bison*, the branches of the ridge angle downwards, forming an upside down Y; the plateau is absent, as the posterior notch extends to the base of the neural spine.

success rate for *Bison*	20/22 = 90.91%
success rate for *Bos*	12/13 = 92.31%

Character #12: neural spine ridges	Aspect 1	Aspect 2	Aspect 3
	angled down	horizontal	intermediate
No. of *Bison*	20/22	1/22	1/22
No. of *Bos*	1/13	12/13	0/13
Preference Factor *Bison*	8.36	0.07	2.40
Preference Factor *Bos*	0.12	14.16	0.42



BISON



BOS

Figure 9. Cervical 5, Posterior View

CERVICAL 5

Fig. 9. Posterior View

(13) In *Bos* the transverse process arises near the middle of the transverse foramen; in *Bison* it arises from below the foramen. This distinction only holds for C.5

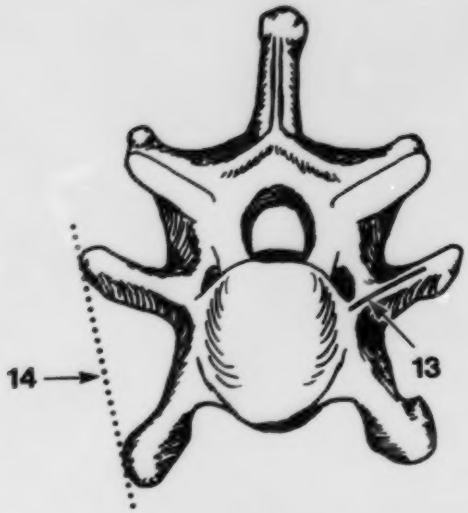
success rate for *Bison*	24/24 = 100.0%
success rate for *Bos*	10/13 = 76.92%

Character #13: transverse process	Aspect 1	Aspect 2	Aspect 3
	below foramen	mid-foramen	intermediate
No. of *Bison*	24/24	0/24	0/24
No. of *Bos*	2/13	10/13	1/13
Preference Factor *Bison*	5.44	0.02	0.14
Preference Factor *Bos*	0.18	51.79	7.26

(14) The ventral branch of the transverse process of C.5 extends laterally almost to the same distance as the lateral branch in *Bison*, but not in *Bos*. This distinction can be readily visualized by holding a ruler across the ends of the two branches: in *Bison* the ruler is almost vertical, whereas in *Bos* it is definitely angled at approximately 30 degrees.

success rate for *Bison*	14/24 = 58.33%
success rate for *Bos*	13/13 = 100.0%

Character #14: transverse process branches	Aspect 1	Aspect 2	Aspect 3
	even	uneven	intermediate
No. of *Bison*	14/24	5/24	5/24
No. of *Bos*	0/13	13/13	0/13
Preference Factor *Bison*	21.71	0.22	8.23
Preference Factor *Bos*	0.05	4.46	0.12



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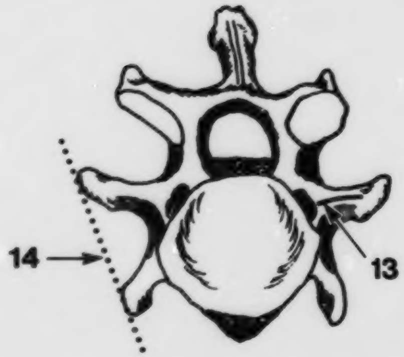


BOS

Figure 9. Cervical 5, Posterior View

CERVICAL 5

Fig. 10. Dorsal View of Anterior Articular Facet

(15) The shape of the anterior articular facet of C.5 is squarish in *Bos*, more rectangular in *Bison*.

success rate for *Bison*	15/23 = 65.22%
success rate for *Bos*	9/13 = 69.23%

Character #15: anterior articular facet	Aspect 1	Aspect 2	Aspect 3
	rectangular	squarish	intermediate
No. of *Bison*	15/23	5/23	3/23
No. of *Bos*	1/13	9/13	3/13
Preference Factor *Bison*	6.05	0.33	0.57
Preference Factor *Bos*	0.17	3.01	1.74

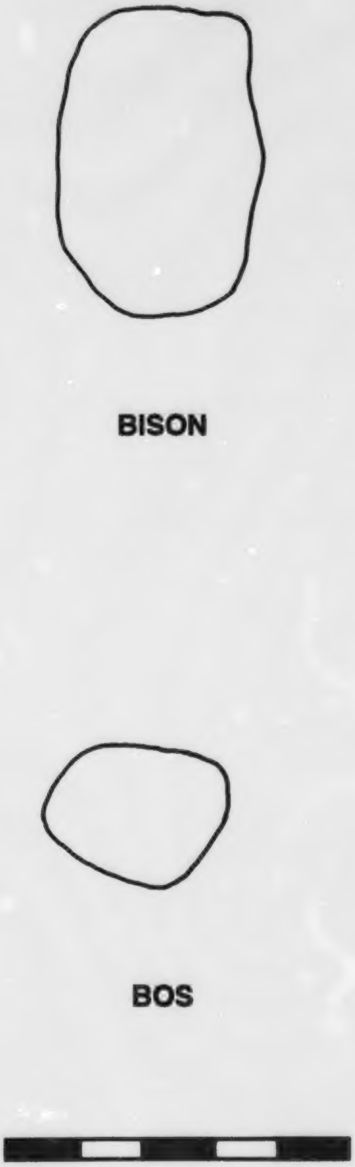


Figure 10. Anterior Articular Facet of Cervical 5, Dorsal View

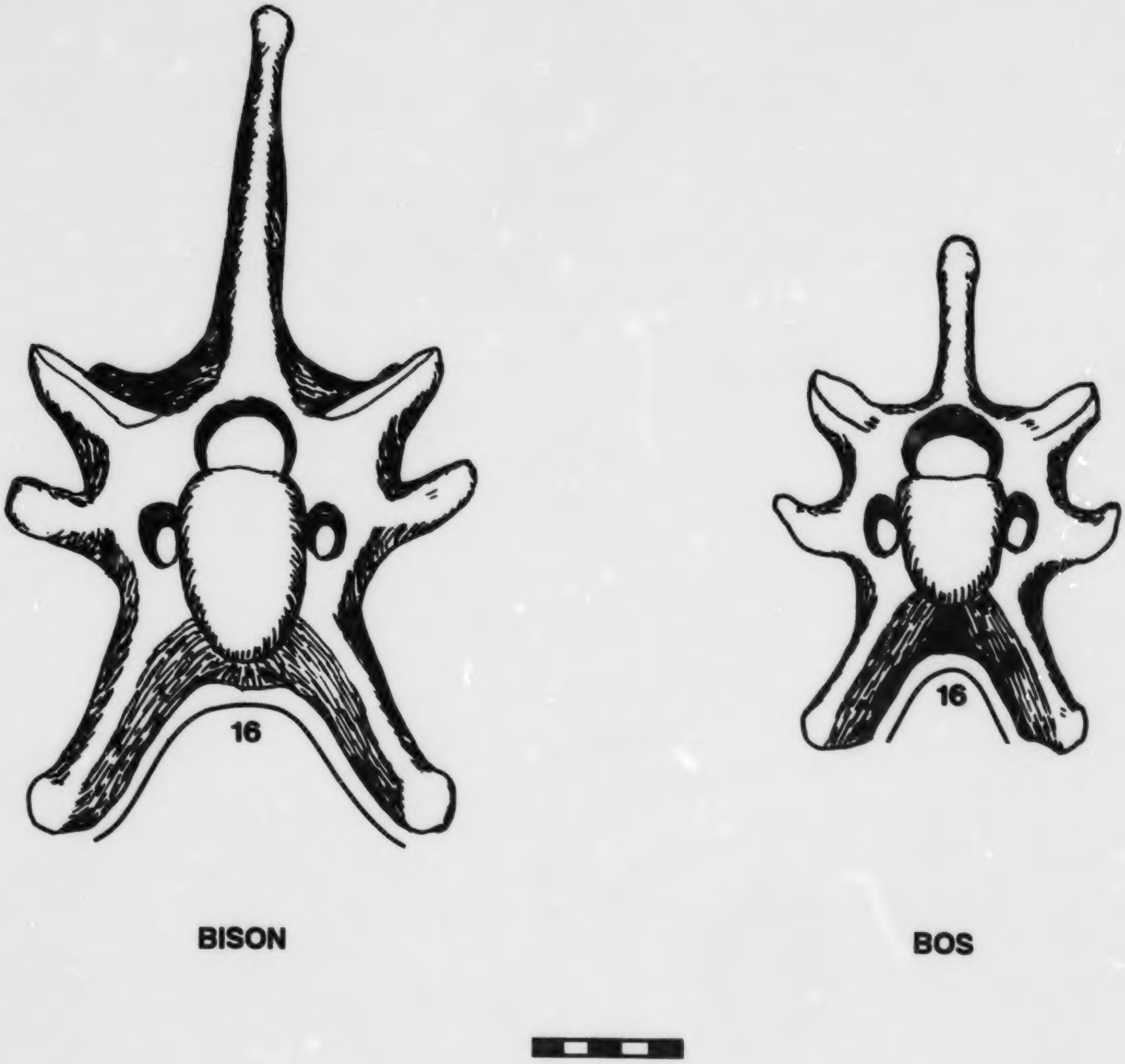
CERVICAL 6

Fig. 11. Anterior View

(16) The angle between the lateral branches of the transverse process of C.6 is wider and deeper in *Bison*, so that the vertebra appears "straddle-legged" in *Bison* but rather squat in *Bos*.

success rate for *Bison*	19/23 = 82.61%
success rate for *Bos*	12/12 = 100.0%

Character #16: shape of "legs"	Aspect 1	Aspect 2	Aspect 3
	straddled	squat	intermediate
No. of *Bison*	19/23	4/23	0/23
No. of *Bos*	0/12	12/12	0/12
Preference Factor *Bison*	28.19	0.19	0.53
Preference Factor *Bos*	0.04	5.23	1.88



BISON

BOS

Figure 11. Cervical 6, Anterior View

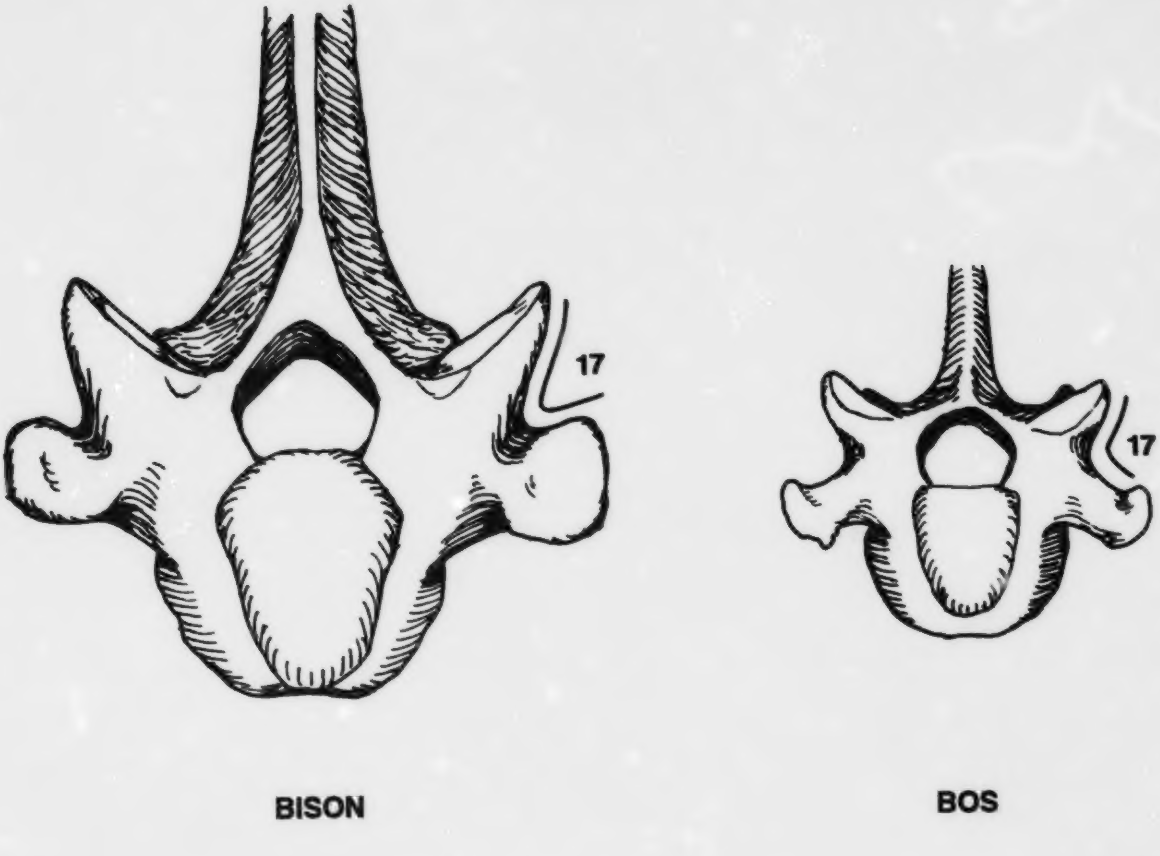
CERVICAL 7

Fig. 12. Anterior View

(17) The transverse process describes an acute angle with the centrum in *Bison*, an obtuse angle in *Bos*.

success rate for *Bison*	24/24 = 100.0%
success rate for *Bos*	11/12 = 91.67%

Character #17: transverse process angle	Aspect 1	Aspect 2	Aspect 3
	acute	obtuse	intermediate
No. of *Bison*	24/24	0/24	0/24
No. of *Bos*	0/12	11/12	1/12
Preference Factor *Bison*	33.97	0.02	0.13
Preference Factor *Bos*	0.03	61.26	7.84



BISON

BOS

Figure 12. Cervical 7, Anterior View

THORACIC VERTEBRAE

There are only a few characteristics to distinguish between the thoracic vertebrae of *Bos* and *Bison*. In both genera, there is a progressive reduction in the size of the transverse process from the anterior to the posterior thoracics; the neural spine becomes shorter from the fourth to the last thoracic; the posterior inclination of the neural spine increases from the first to the tenth thoracic; and the spine becomes narrower anteroposteriorly from the first to the twelfth thoracic vertebra.

It is helpful to separate the thoracics into three groups (anterior, mid, and posterior), based on the following distinctions:

Anterior Thoracics (T.1-T.4): see Fig. 13

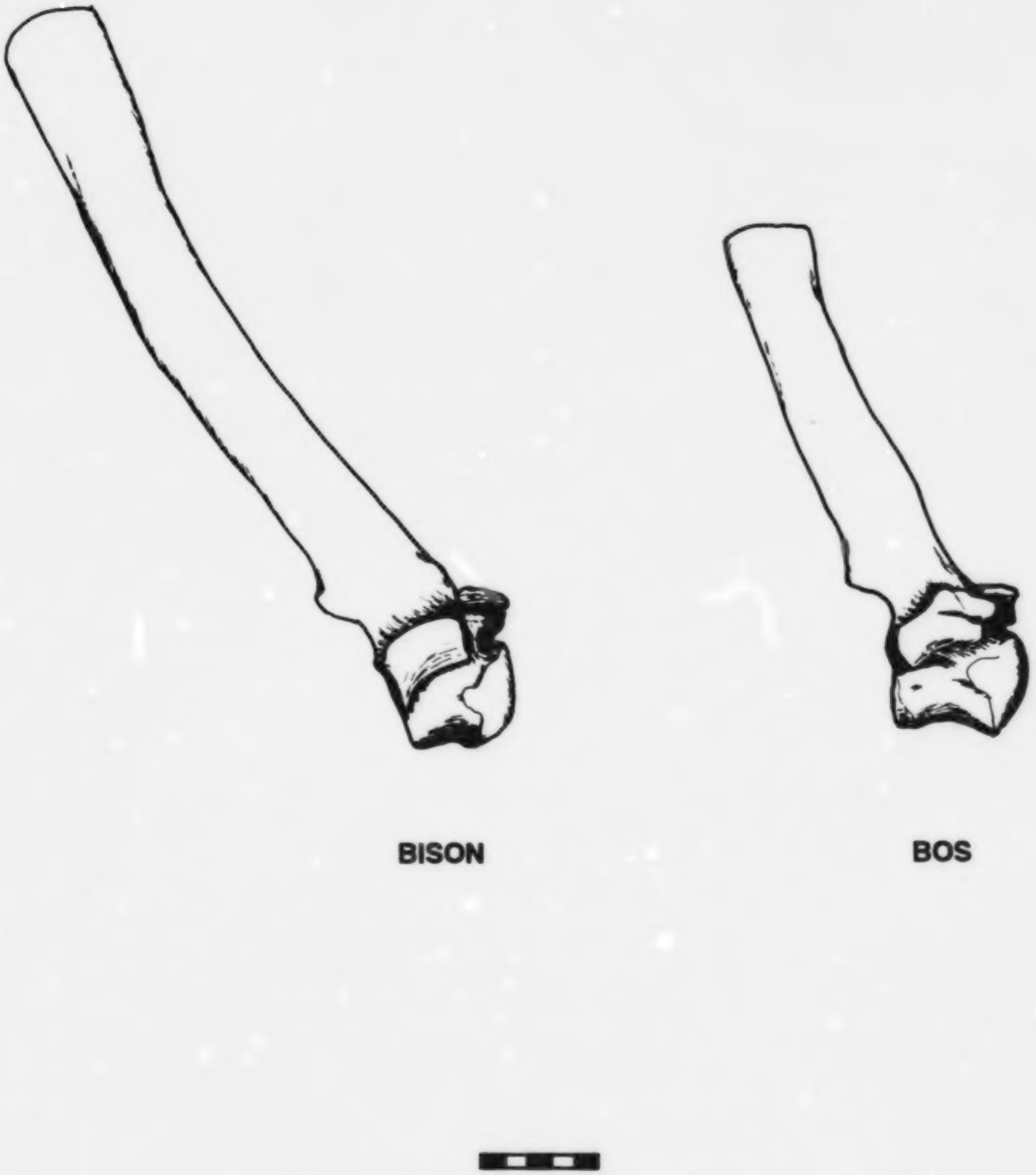
- the neural spine is very long and wide anteroposteriorly;
- the transverse process is large, rounded and deep dorsoventrally;
- the posterior inclination of the neural spine is less than in the mid-thoracics;
- there is a distinct break between the anterior articular facets and the base of the neural spine.

Mid Thoracics (T.5-T.10): see Fig. 15

- the neural spine becomes progressively shorter as well as narrower anteroposteriorly;
- the transverse process becomes smaller, with the decrease in the dorsoventral depth especially noticeable;
- the neural spine has a pronounced posterior inclination;
- with the exception of the fifth thoracic, the anterior articular facets appear more continuous with the curve at the base of the neural spine.

Posterior Thoracics (T.11-T.13 or T.14): not illustrated

- the neural spine is short but the anteroposterior depth is greater than in the mid-thoracics;
- the posterior inclination of the neural spine decreases;
- the posterior articular processes are more prominent and complex;
- there is a distinct separation between the transverse process and the anterior articular process.



BISON

BOS

Figure 13. First Thoracic Vertebra, Lateral View

THORACIC VERTEBRAE

Fig. 14. First Thoracic Vertebra, Lateral View

(1) The anterior margin at the base of the neural spine is "humped" in *Bison*, but in *Bos* it sweeps smoothly back and up.

success rate for *Bison*	23/24 = 95.83%
success rate for *Bos*	10/13 = 76.92%

Character #1: margin at base of neural spine	Aspect 1	Aspect 2	Aspect 3
	humped	smooth	intermediate
No. of *Bison*	23/24	0/24	1/24
No. of *Bos*	3/13	10/13	0/13
Preference Factor *Bison*	3.71	0.02	2.20
Preference Factor *Bos*	0.27	51.79	0.45

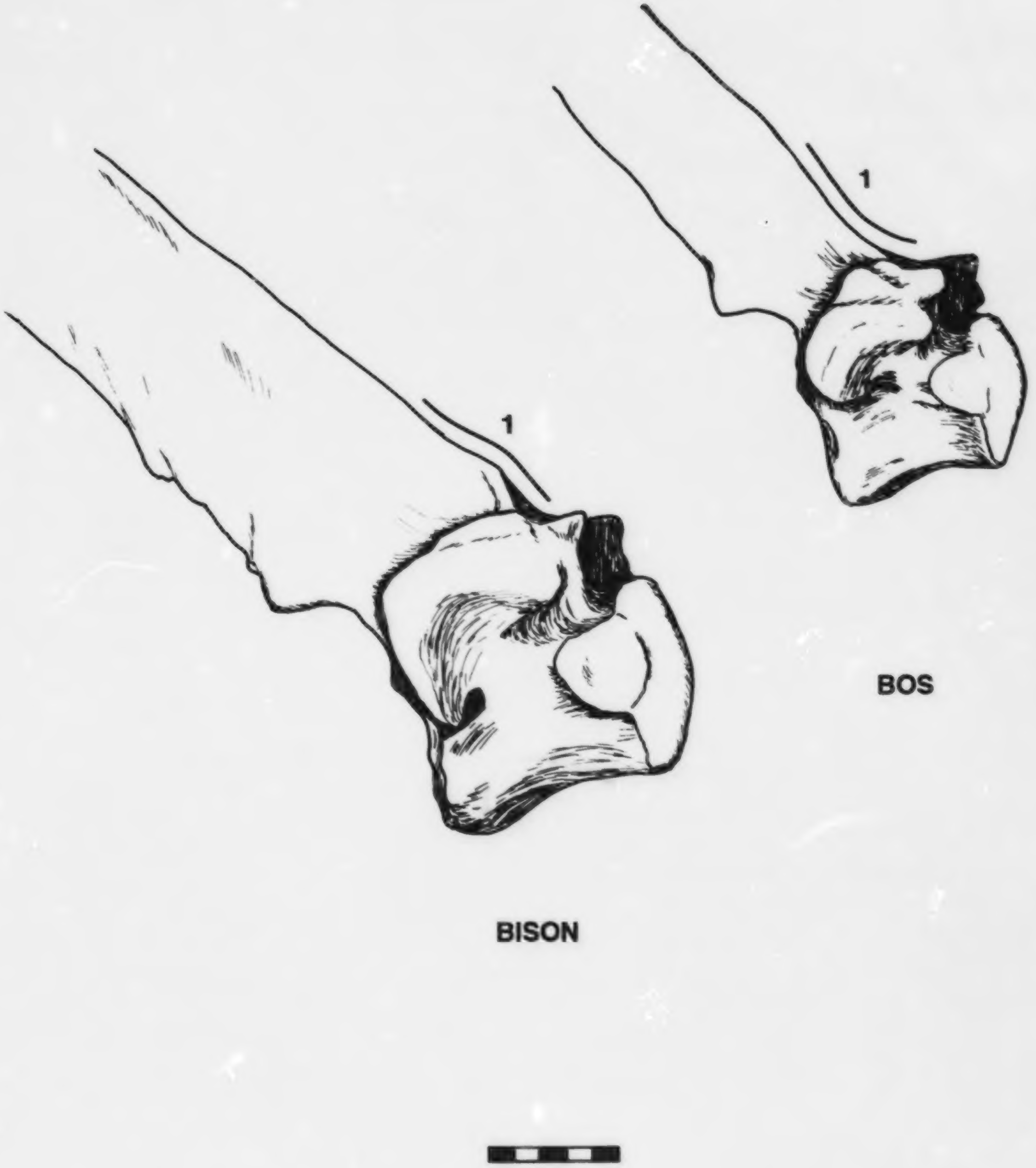

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Figure 14. First Thoracic Vertebra, Lateral View

THORACIC VERTEBRAE

Fig. 15. Lateral View

(2) The antero-posterior depth of the spine is greater in adult *Bison* than in *Bos*; however, young *Bison* are very similar to adult *Bos* in this respect. The difference between female *Bison* and adult *Bos* is slight, but there is a difference.

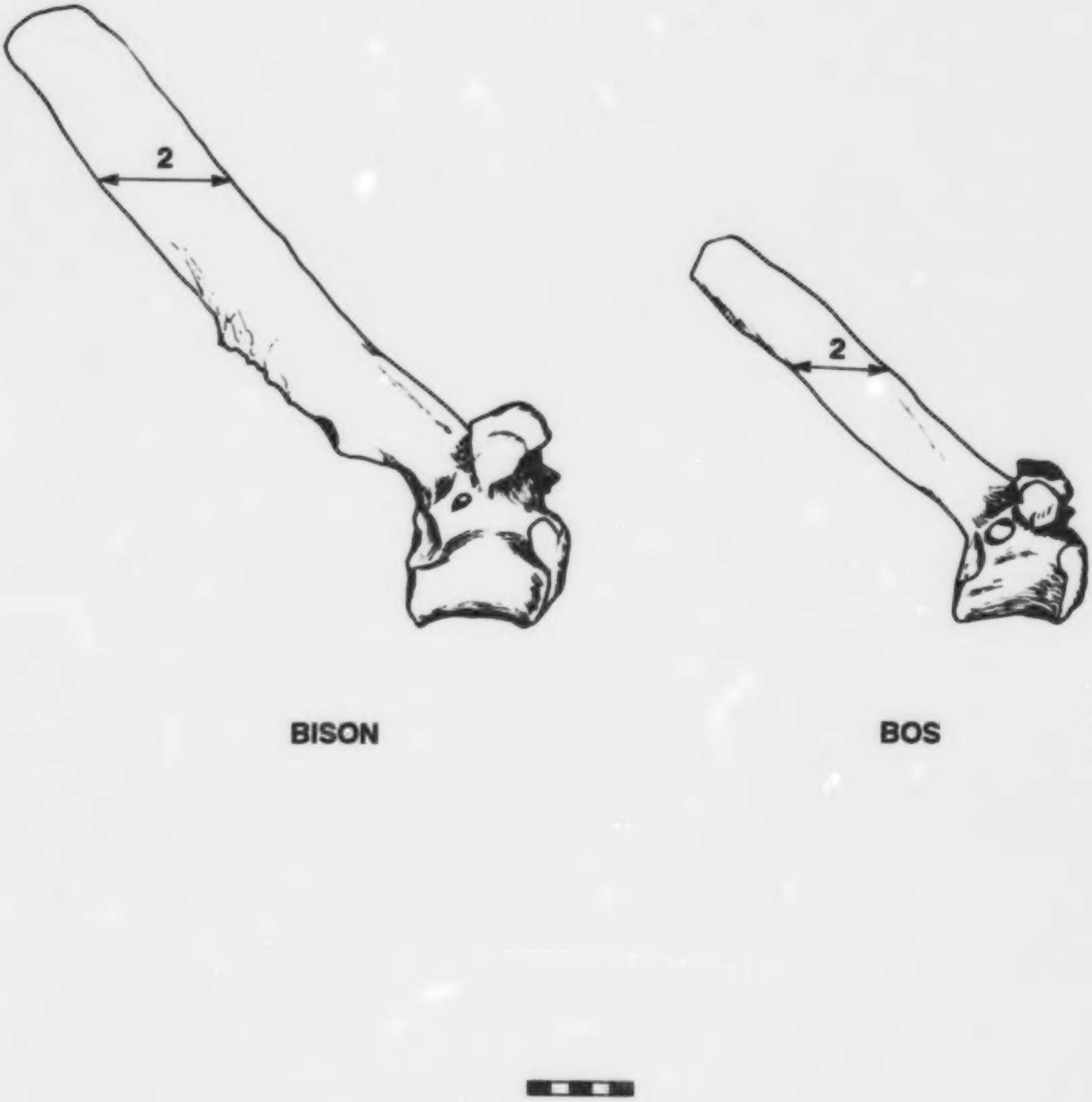
success rate for *Bison*	22/24 = 91.67%
success rate for *Bos*	10/13 = 76.92%

Character #2: antero-posterior depth of spine	Aspect 1	Aspect 2	Aspect 3
	greater	lesser	intermediate
No. of *Bison*	22/24	1/24	1/24
No. of *Bos*	3/13	10/13	0/13
Preference Factor *Bison*	3.55	0.08	2.20
Preference Factor *Bos*	0.28	12.95	0.45

(3) The length of the neural spine is much greater in *Bison*. This character is useful in eliminating young *Bos* (i.e. the spine can just be too long for *Bos*) especially if you can determine whether the vertebra is an anterior thoracic, a mid-thoracic, or a posterior thoracic vertebra. (Shown but not marked)

success rate for *Bison*	25/25 = 100.0%
success rate for *Bos*	13/13 = 100.0%

Character #3: length of neural spine	Aspect 1	Aspect 2	Aspect 3
	greater	lesser	intermediate
No. of *Bison*	25/25	0/25	0/25
No. of *Bos*	0/13	13/13	0/13
Preference Factor *Bison*	36.69	0.01	0.53
Preference Factor *Bos*	0.03	69.31	1.89



BISON

BOS

Figure 15. Seventh Thoracic Vertebra, Lateral View

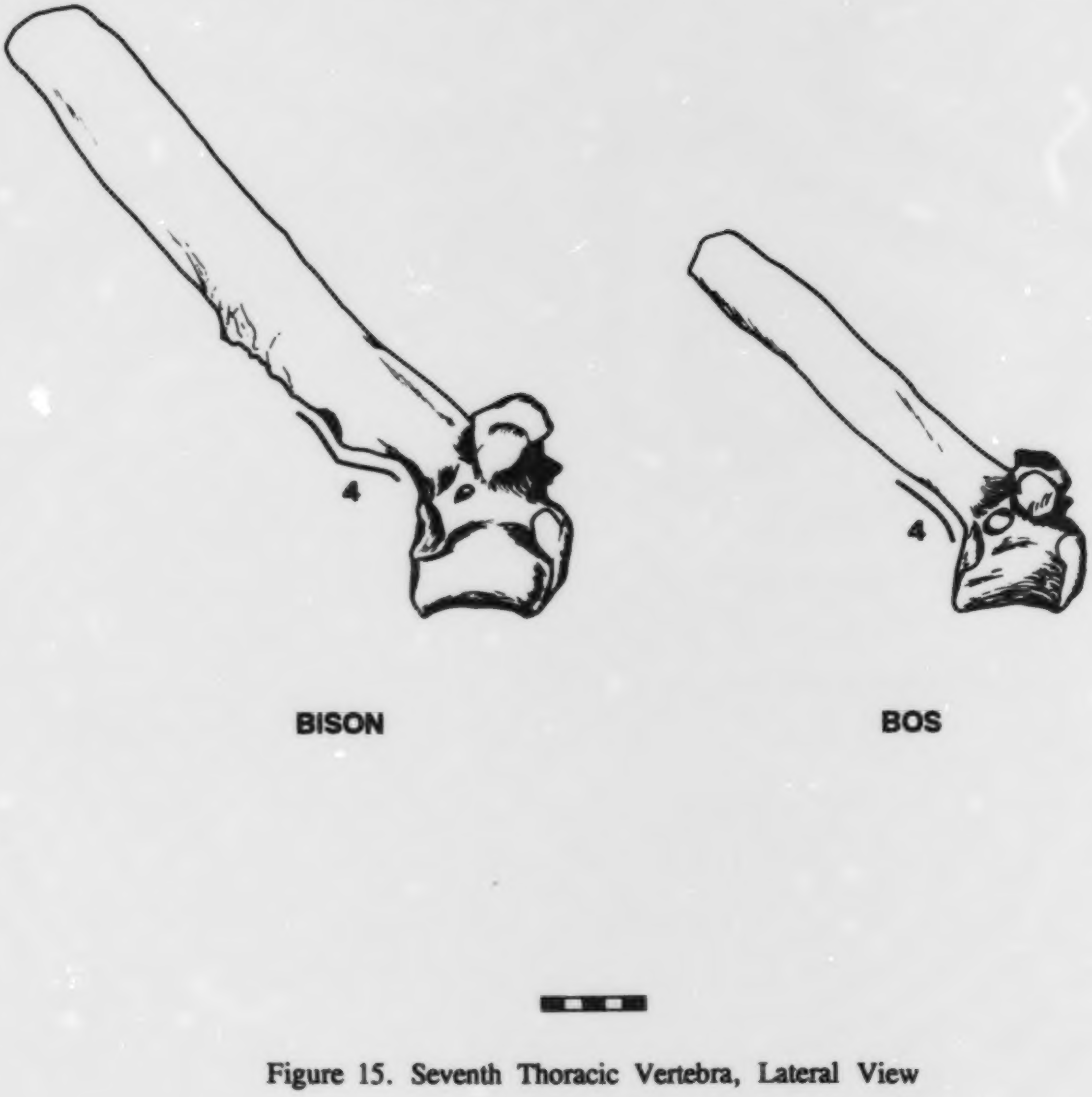
THORACIC VERTEBRAE

Fig. 15. Lateral View

(4) The curve of the posterior articular facets appears more pronounced in *Bison* and there is a definite break in the posterior margin of the neural spine. In *Bos* the curve is slight and appears more continuous with this posterior margin. As an exception to this, the first three thoracics of *Bos* more closely resemble the seventh thoracic of *Bison* than the seventh thoracic of *Bos* in this respect.

success rate for *Bison*	25/25 = 100.0%
success rate for *Bos*	9/13 = 69.23%

Character #4: posterior articular facet curve	Aspect 1	Aspect 2	Aspect 3
	large, with break	slight and smooth	intermediate
No. of *Bison*	25/25	0/25	0/25
No. of *Bos*	3/13	9/13	1/13
Preference Factor *Bison*	3.87	0.02	0.13
Preference Factor *Bos*	0.26	48.76	7.56



BISON

BOS

Figure 15. Seventh Thoracic Vertebra, Lateral View

RIBS

Fig. 16. Postero-Medial View

(1) *Bos* shows a noticeable flaring in the shaft of all ribs, being rather trapezoidal in shape, with the narrow part towards the proximal end of the rib. *Bison* is almost parallel-sided, although there is a slight flaring in ribs 6-8, but not nearly to the extent shown by the corresponding ribs in *Bos*.

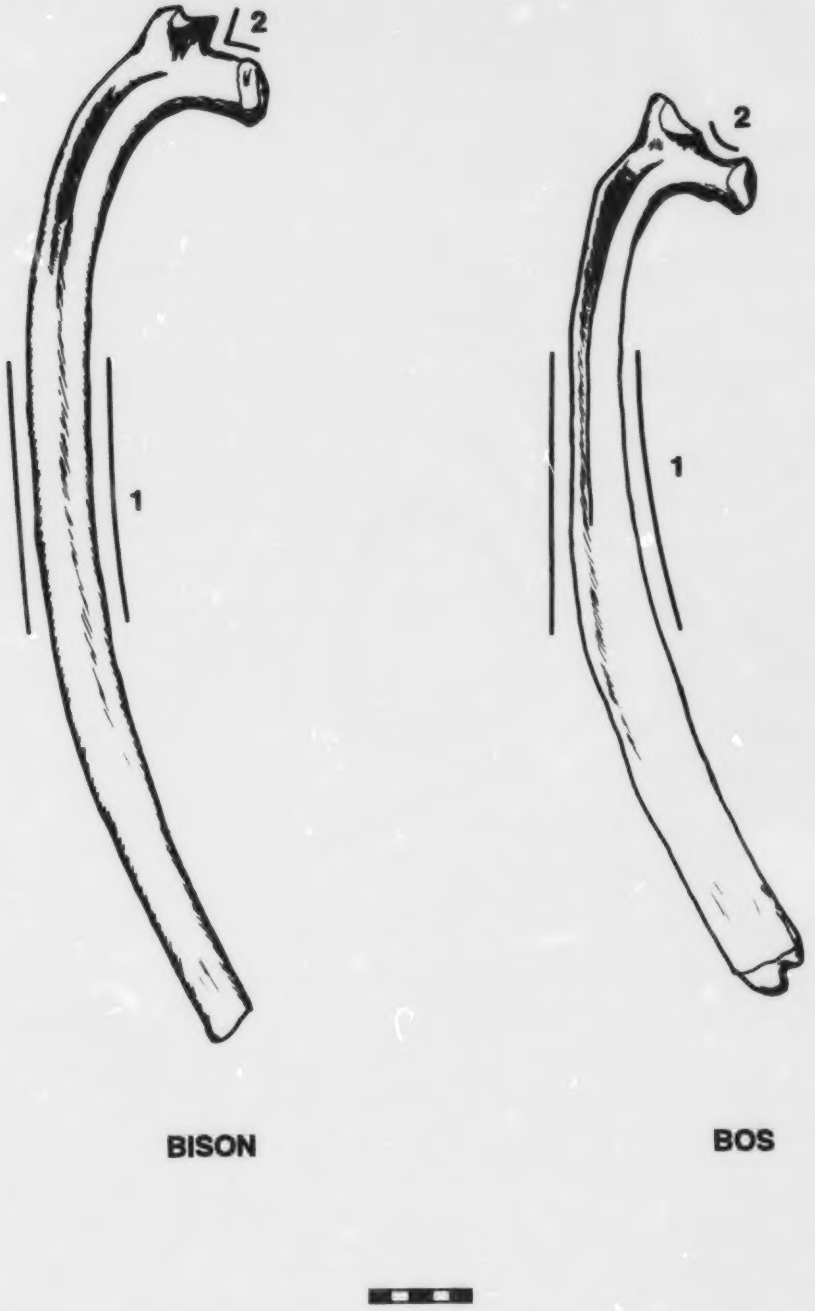
success rate for *Bison*	25/25 = 100.0%
success rate for *Bos*	15/15 = 100.0%

Character #1: margins of shaft	Aspect 1 parallel	Aspect 2 flared	Aspect 3 intermediate
No. of *Bison*	25/25	0/25	0/25
No. of *Bos*	0/15	15/15	0/15
Preference Factor *Bison*	10.53	0.06	4.10
Preference Factor *Bos*	0.09	17.33	0.24

(2) The anterior margin of the tubercle of the first six ribs rises almost straight up in *Bison*, but is tilted towards the head of the rib in *Bos*.

success rate for *Bison*	22/25 = 88.00%
success rate for *Bos*	4/12 = 33.33%

Character #2: anterior margin of tubercle	Aspect 1 straight	Aspect 2 tilted	Aspect 3 intermediate
No. of *Bison*	22/25	3/25	0/25
No. of *Bos*	7/12	4/12	1/12
Preference Factor *Bison*	1.47	0.38	0.12
Preference Factor *Bos*	0.68	2.63	8.16



BISON

BOS

Figure 16. Left Fifth Rib, Postero-Medial View

RIBS

Fig. 16. Postero-Medial View

(3) The shaft narrows towards the distal end in *Bison* but not in *Bos*. This difference is particularly noticeable in the mid-ribs.

success rate for *Bison*	25/25 = 100.0%
success rate for *Bos*	11/13 = 84.62%

Character #3: distal shaft narrowing	Aspect 1	Aspect 2	Aspect 3
	present	absent	intermediate
No. of *Bison*	25/25	0/25	0/25
No. of *Bos*	1/13	11/13	1/13
Preference Factor *Bison*	9.17	0.02	0.13
Preference Factor *Bos*	0.11	59.04	7.56

(4) The costal groove is wider in *Bison* than in *Bos*; this is particularly noticeable in ribs 9-11. (Shown but not marked)

success rate for *Bison*	25/25 = 100.0%
success rate for *Bos*	9/14 = 64.29%

Character #4: costal groove shape	Aspect 1	Aspect 2	Aspect 3
	wider	narrower	intermediate
No. of *Bison*	25/25	0/25	0/25
No. of *Bos*	5/14	9/14	0/14
Preference Factor *Bison*	2.64	0.02	0.57
Preference Factor *Bos*	0.38	45.40	1.76

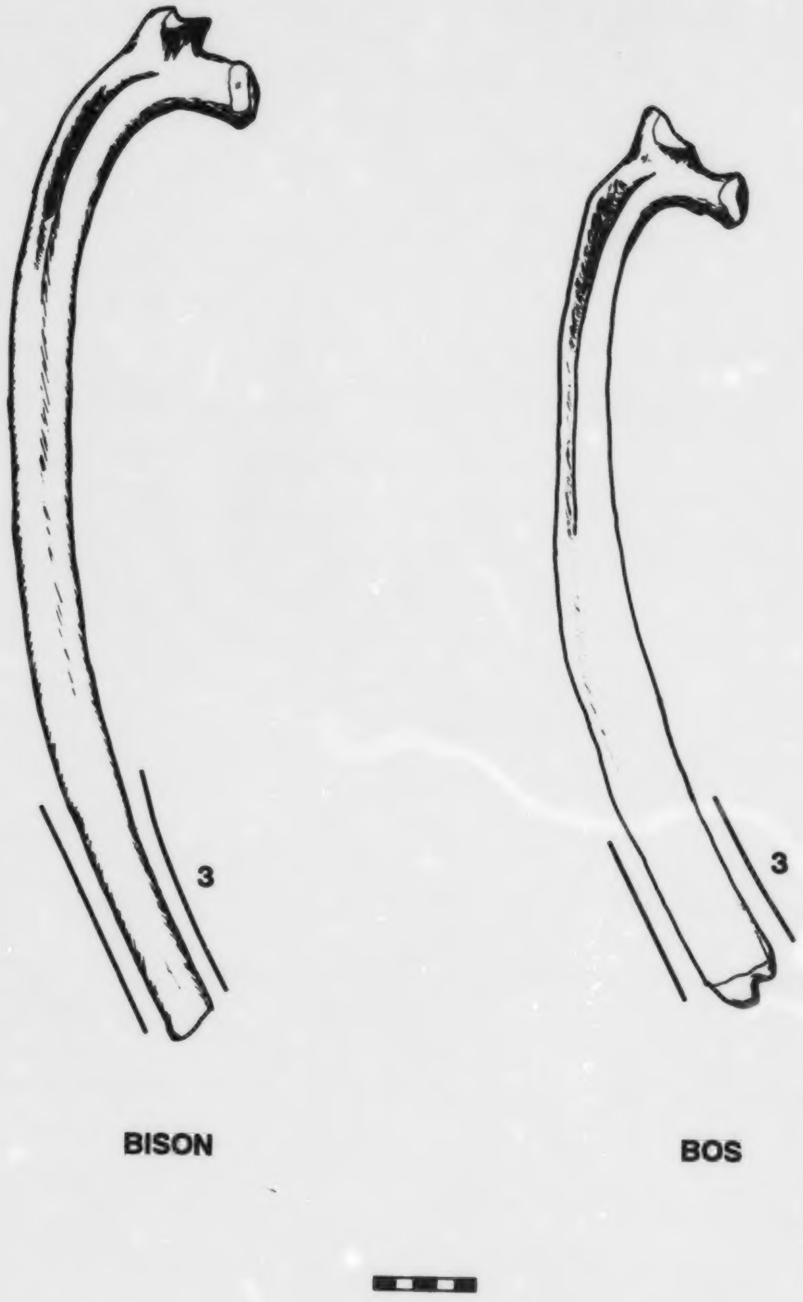

3
3
BISON
BOS

Figure 16. Left Fifth Rib, Postero-Medial View

RIBS

Fig. 17. Antero-Medial View

(5) For ribs 1-6, the tubercle flares out more in *Bison* than in *Bos*.

success rate for *Bison*	24/24 = 100.0%
success rate for *Bos*	11/12 = 91.67%

Character #5: flaring of tubercle	Aspect 1	Aspect 2	Aspect 3
	greater	lesser	intermediate
No. of *Bison*	24/24	0/24	0/24
No. of *Bos*	1/12	11/12	0/12
Preference Factor *Bison*	8.49	0.02	0.51
Preference Factor *Bos*	0.12	61.26	1.96

(6) For ribs 3-8, more of the proximal surface of the posterior part of the tubercle is visible in *Bos* than in *Bison*.

success rate for *Bison*	23/24 = 95.83%
success rate for *Bos*	12/12 = 100.0%

Character #6: proximal surface of tubercle	Aspect 1	Aspect 2	Aspect 3
	less visible	more visible	intermediate
No. of *Bison*	23/24	0/24	1/24
No. of *Bos*	0/12	12/12	0/12
Preference Factor *Bison*	32.58	0.02	2.04
Preference Factor *Bos*	0.03	66.59	0.49

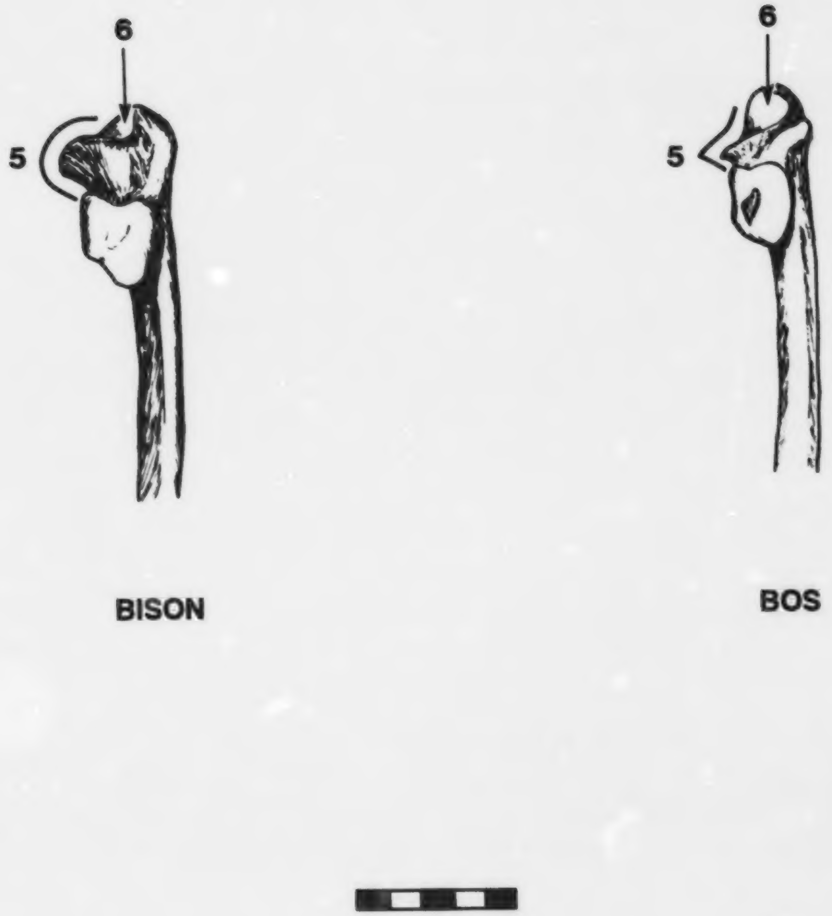

6
5
BISON
6
5
BOS

Figure 17. Proximal End of Third Rib, Antero-Medial View

RIBS

Fig. 17. Antero-Medial View

(7) *Bos* have a small tuberosity on the anterior surface near the tubercle of ribs 2-6; this tuberosity is not apparent in *Bison*. This distinction is most noticeable in ribs 2 and 3. However, in the first rib the situation is reversed, with the tuberosity present in *Bison* but not in *Bos*.

success rate for *Bison*	21/25 = 84.00%
success rate for *Bos*	7/12 = 58.33%

Character #7: small tuberosity	Aspect 1	Aspect 2	Aspect 3
	absent	present	intermediate
No. of *Bison*	21/25	0/25	4/25
No. of *Bos*	5/12	7/12	0/12
Preference Factor *Bison*	1.92	0.02	5.98
Preference Factor *Bos*	0.52	41.57	0.17

(8) For ribs 1-7, the groove for the intraarticular ligament attachment in the head of the rib is better developed in *Bos* than in *Bison*.

success rate for *Bison*	16/20 = 80.00%
success rate for *Bos*	10/12 = 83.33%

Character #8: groove in head	Aspect 1	Aspect 2	Aspect 3
	less developed	well developed	intermediate
No. of *Bison*	16/20	2/20	2/20
No. of *Bos*	2/12	10/12	0/12
Preference Factor *Bison*	4.05	0.14	4.12
Preference Factor *Bos*	0.25	6.93	0.24

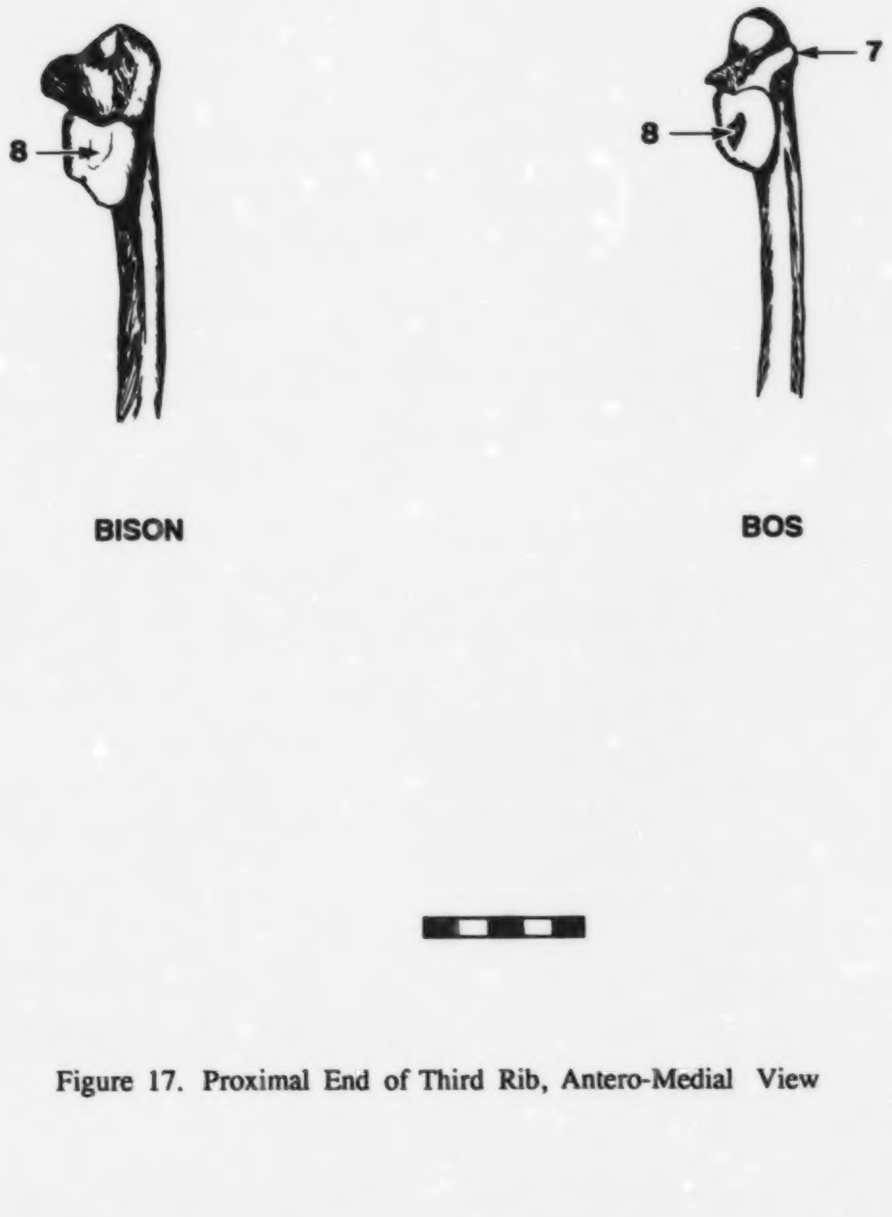

8
7
8
BISON
BOS

Figure 17. Proximal End of Third Rib, Antero-Medial View

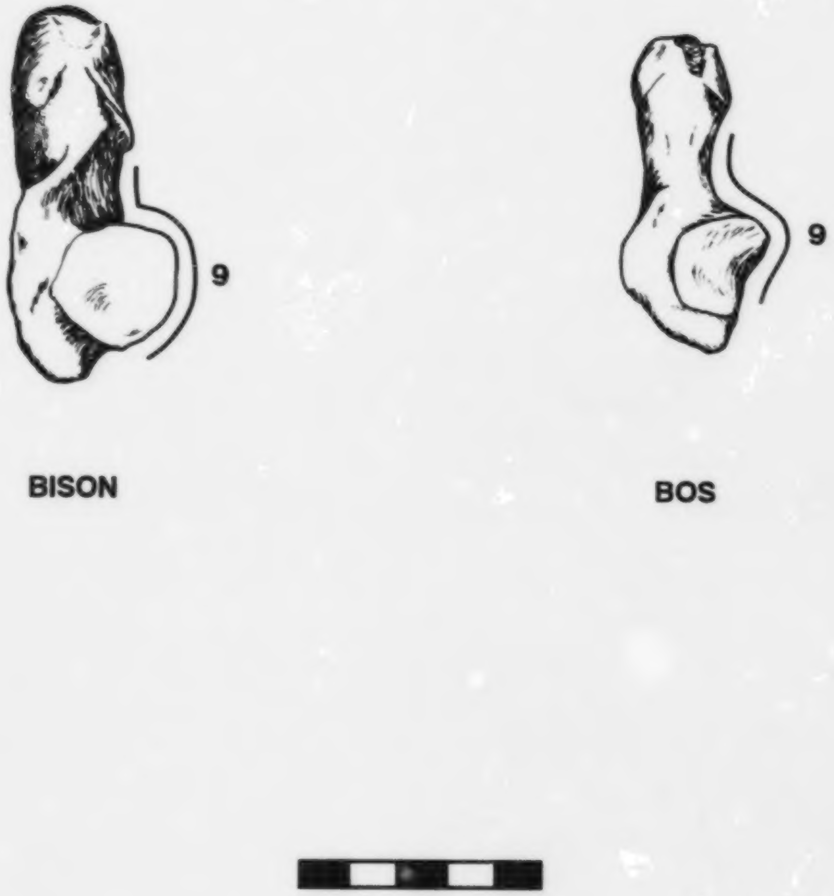
RIBS

Fig. 18. Dorsal View of Fifth Rib

(9) Note the difference in the angle and degree of flaring of the tubercle. When viewed dorsally, all the ribs from 1-8 show a greater degree of flaring in the anterior part of the tubercle of *Bison* than of *Bos*. This distinction can also be seen in an antero-medial view (Fig. 17). However, in the 9th and 10th ribs the posterior part of the tubercle is more flared in *Bos*, as can be seen in Fig. 19. In the 11th and 12th ribs the tubercle appears flared to the same extent in *Bos* and *Bison*.

success rate for *Bison*	22/25 = 88.0%
success rate for *Bos*	12/12 = 100.0%

Character #9: flare of tubercle, ribs 1-8	Aspect 1	Aspect 2	Aspect 3
	greater	lesser	intermediate
No. of *Bison*	22/25	1/25	2/25
No. of *Bos*	0/12	12/12	0/12
Preference Factor *Bison*	29.97	0.06	3.31
Preference Factor *Bos*	0.03	17.33	0.30



BISON

BOS

Figure 18. Left Fifth Rib, Dorsal View

RIBS

Fig. 18. Dorsal View of Fifth Rib

(10) *Bison* show a pronounced curved ridge running diagonally from the medial side of the head to the lateral side of the tubercle in ribs 4 & 5. For ribs 6-14 the almost straight ridge runs from the middle of the head to the lateral side of the tubercle, although it is reduced in the more posterior ribs. This ridge is not apparent in *Bos*.

success rate for *Bison*	21/24 = 87.50%
success rate for *Bos*	6/13 = 46.15%

Character #10: dorsal ridge, ribs 4-14	Aspect 1	Aspect 2	Aspect 3
	present	absent	intermediate
No. of *Bison*	21/24	3/24	0/24
No. of *Bos*	5/13	6/13	2/13
Preference Factor *Bison*	2.16	0.30	0.08
Preference Factor *Bos*	0.46	3.38	12.25

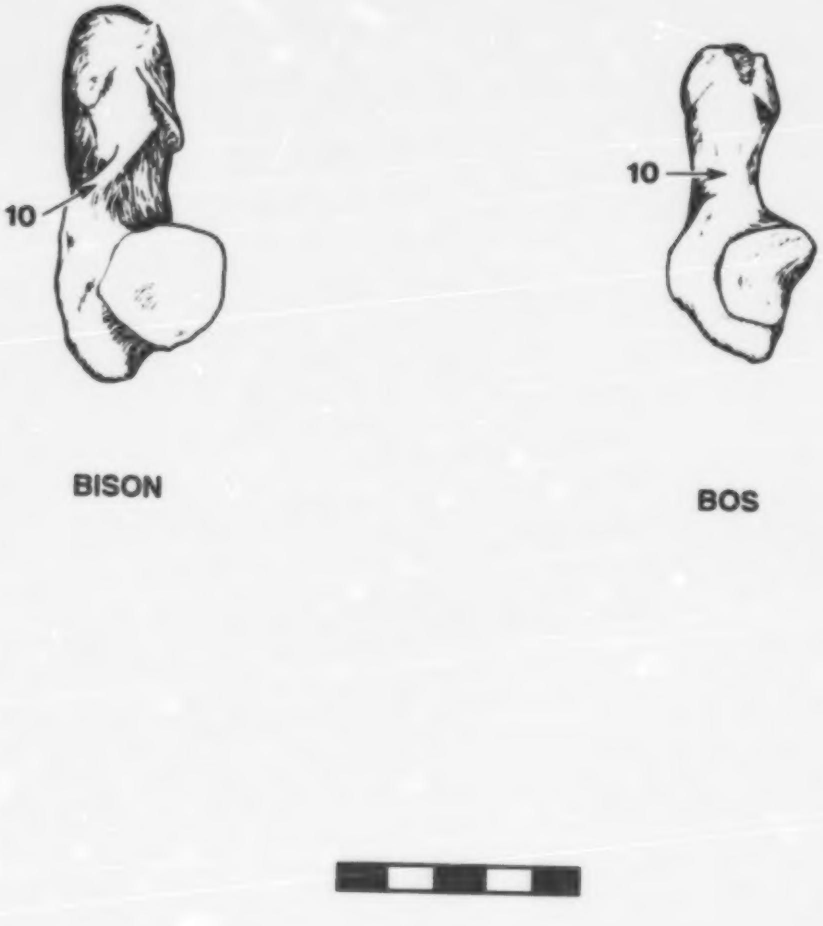

10
10
BISON
BOS

Figure 18. Left Fifth Rib, Dorsal View

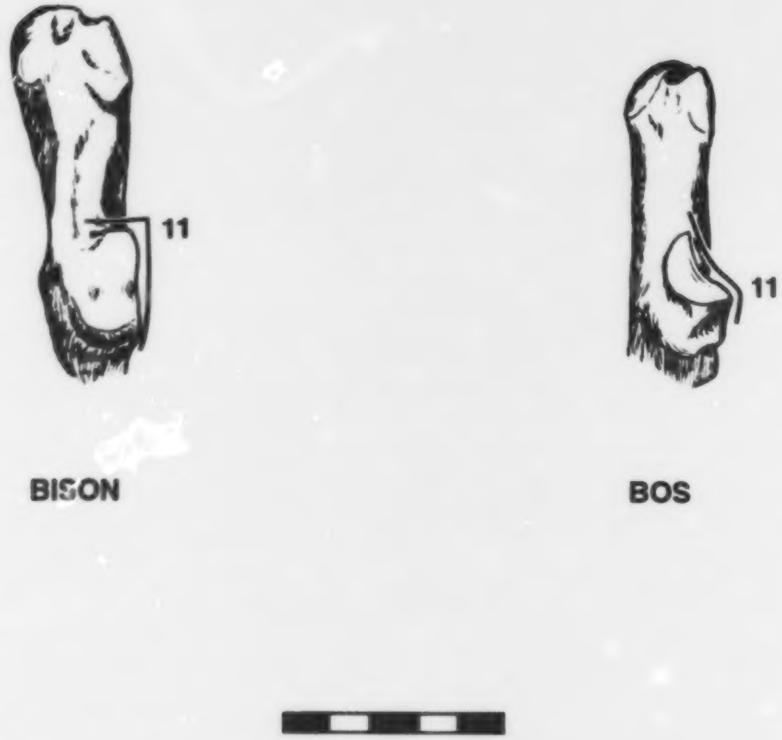
RIBS

Fig. 19. Dorsal View of Ninth Rib

(11) In *Bison* the anterior part of the tubercle of ribs 9 and 10 is slightly flared out. In *Bos* it is the posterior part of the tubercle which is flared out.

success rate for *Bison*	13/22 = 59.09%
success rate for *Bos*	9/12 = 75.00%

Character #11: flare of tubercle, ribs 9 and 10	Aspect 1	Aspect 2	Aspect 3
	anterior part flared	posterior part flared	intermediate
No. of *Bison*	13/22	5/22	4/22
No. of *Bos*	2/12	9/12	1/12
Preference Factor *Bison*	3.02	0.32	1.70
Preference Factor *Bos*	0.33	3.11	0.59



BISON

BOS

Figure 19. Left Ninth Rib, Dorsal View

RIBS

Fig. 20. Posterior View

(12) The flange along the posterior margin of the shaft of the middle and posterior ribs is much better developed in *Bos* than in *Bison*.

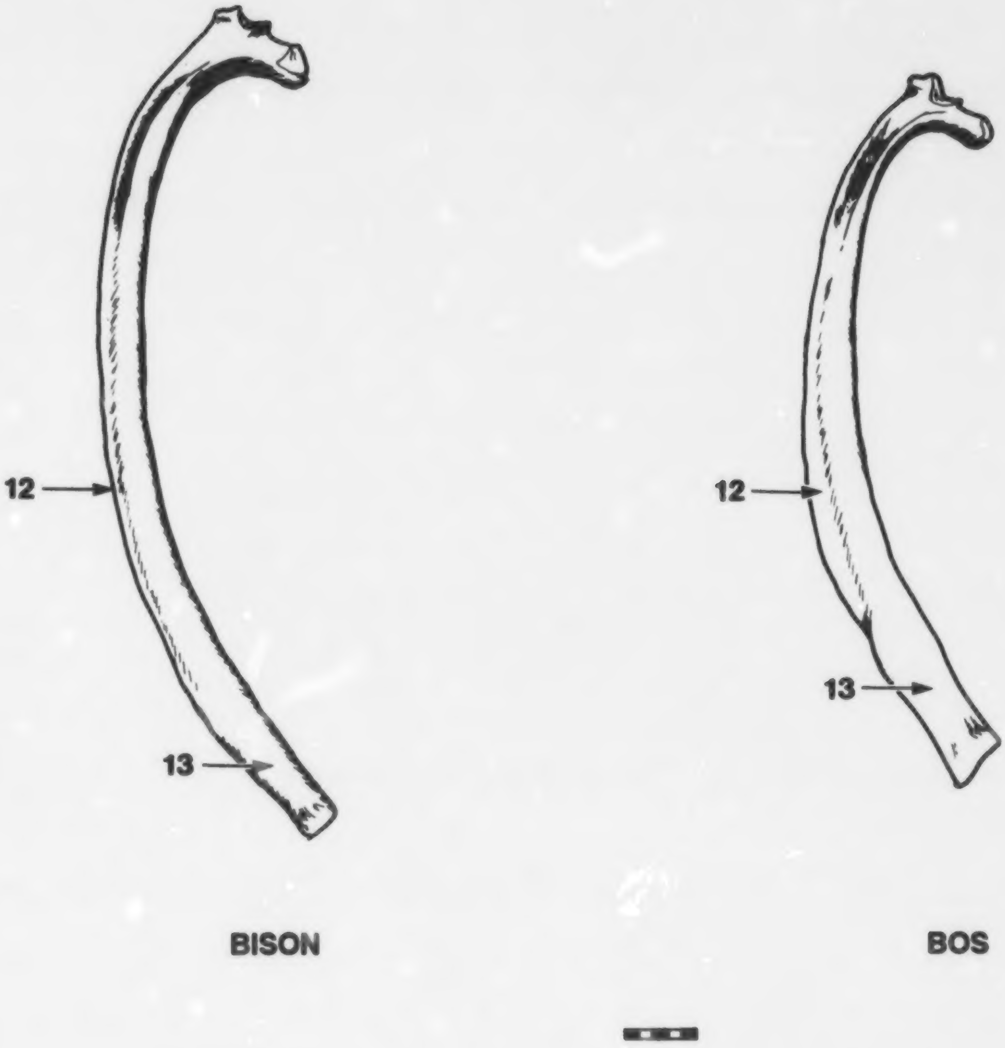
success rate for *Bison*	25/25 = 100.0%
success rate for *Bos*	15/15 = 100.0%

Character #12: flange development	Aspect 1	Aspect 2	Aspect 3
	poor	good	intermediate
No. of *Bison*	25/25	0/25	0/25
No. of *Bos*	0/15	15/15	0/15
Preference Factor *Bison*	42.13	0.01	0.61
Preference Factor *Bos*	0.02	69.31	1.65

(13) For the first ten ribs, the medial surface of the distal third of the rib is rounded in *Bison* and flattened in *Bos*. This distinction does not hold for ribs 11-14, which are flattened in both genera.

success rate for *Bison*	24/25 = 96.00%
success rate for *Bos*	15/15 = 100.0%

Character #13: distal medial surface	Aspect 1	Aspect 2	Aspect 3
	rounded	flattened	intermediate
No. of *Bison*	24/25	1/25	0/25
No. of *Bos*	0/15	15/15	0/15
Preference Factor *Bison*	40.47	0.06	0.61
Preference Factor *Bos*	0.02	17.33	1.65



BISON

BOS

Figure 20. Left Seventh Rib, Posterior View

RIBS

Fig. 20. Posterior View

(14) For all ribs except the first, the distal end of the *Bison* rib has a smaller circumference than that of *Bos*.

success rate for *Bison*	24/25 = 96.00%
success rate for *Bos*	13/14 = 92.86%

Character #14: circumference of distal end	Aspect 1 smaller	Aspect 2 larger	Aspect 3 intermediate
No. of *Bison*	24/25	0/25	1/25
No. of *Bos*	1/14	13/14	0/14
Preference Factor *Bison*	9.47	0.02	2.27
Preference Factor *Bos*	0.11	64.53	0.44

(15) In *Bison* the shaft of the rib gives a general impression of roundness, squareness or bulkiness, whereas in *Bos* the impression is one of flatness. This distinction is particularly noticeable in posterior view. (Shown but not marked).

success rate for *Bison*	23/25 = 92.00%
success rate for *Bos*	15/15 = 100.0%

Character #15: general impression of shaft	Aspect 1 bulkiness	Aspect 2 flatness	Aspect 3 intermediate
No. of *Bison*	23/25	1/25	1/25
No. of *Bos*	0/15	15/15	0/15
Preference Factor *Bison*	38.82	0.06	2.43
Preference Factor *Bos*	0.03	17.33	0.41

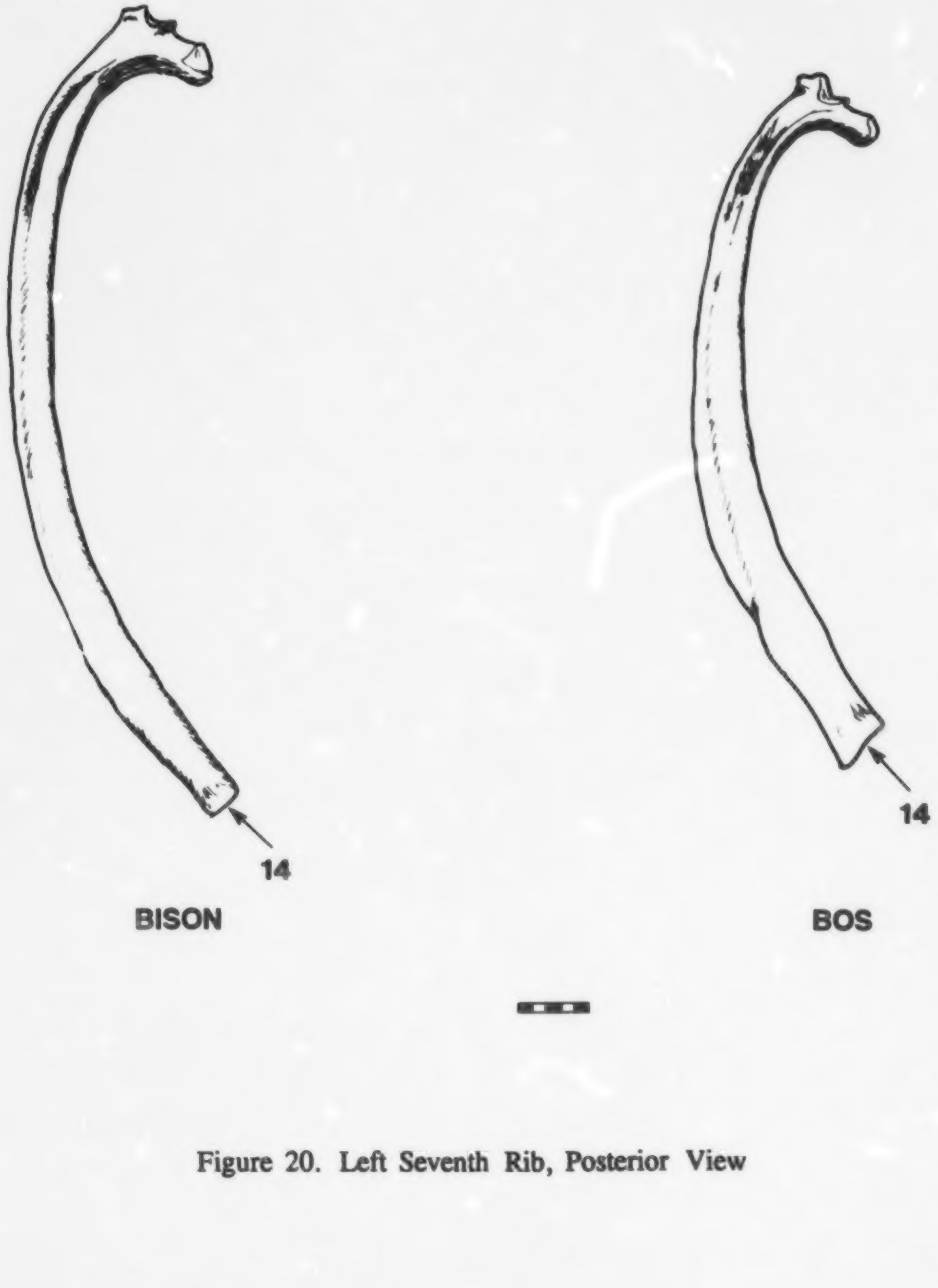

14
BISON
14
BOS

Figure 20. Left Seventh Rib, Posterior View

LUMBAR VERTEBRAE

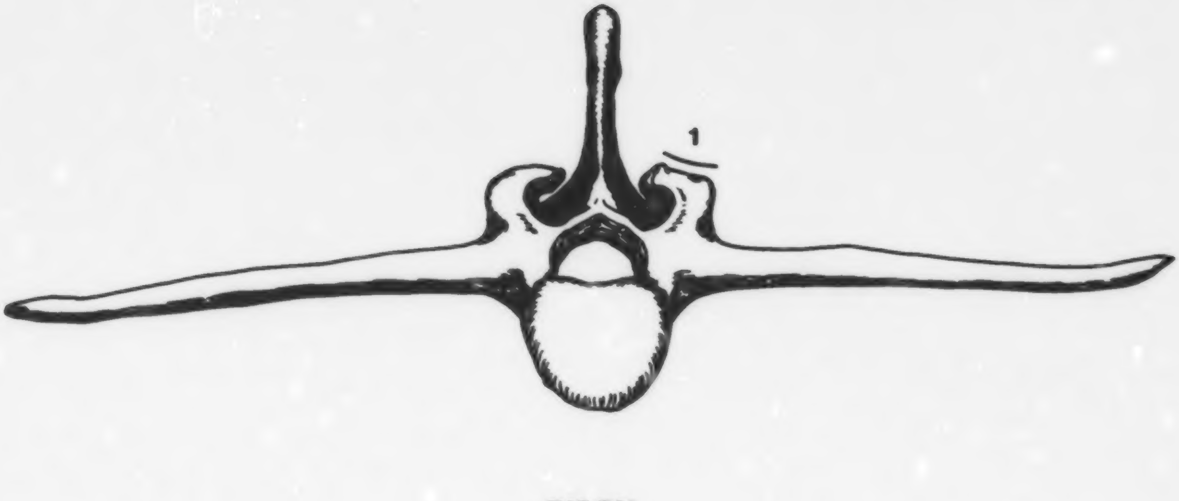
In both *Bos* and *Bison*, the following changes can be noticed as one moves from the first to the last lumbar vertebra: the transverse process becomes longer and thinner; the posterior end of the centrum becomes more and more ovoid; and the separation between the posterior articular processes becomes wider.

Fig. 21. Anterior View

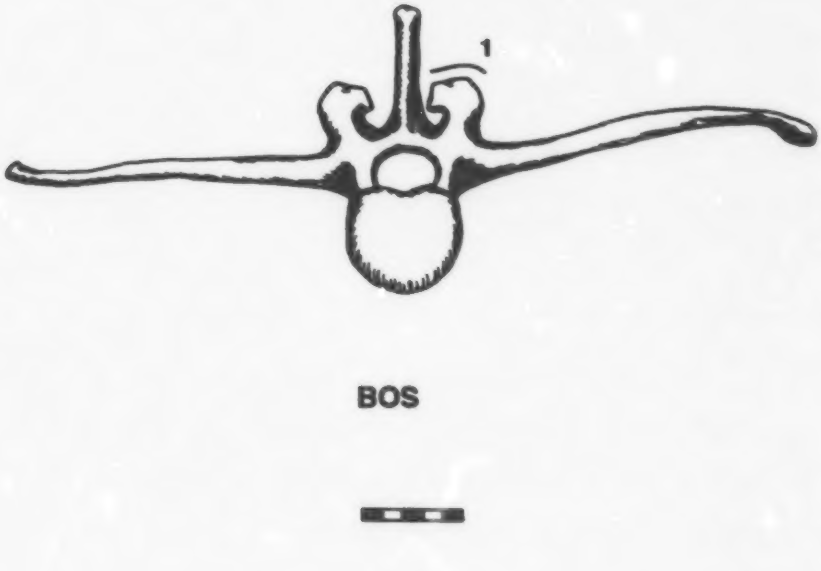
(1) The dorsal margin of the anterior articular process is level with or below the top of the articular facet in *Bison*, but above the facet in *Bos*. This distinction applies to all lumbar vertebrae.

success rate for *Bison*	22/24 = 91.67%
success rate for *Bos*	11/13 = 84.62%

Character #1: dorsal margin of articular process	Aspect 1	Aspect 2	Aspect 3
	level or below	above	intermediate
No. of *Bison*	22/24	0/24	2/24
No. of *Bos*	2/13	11/13	0/13
Preference Factor *Bison*	4.99	0.02	3.72
Preference Factor *Bos*	0.20	56.72	0.27



BISON



BOS

Figure 21. Third Lumbar Vertebra, Anterior View

LUMBAR VERTEBRAE

Fig. 22. Dorsal View

(2) The posterior border of the anterior articular facet is well behind the anterior edge of the base of the neural spine in *Bison*, more nearly even in *Bos*. This generally holds for all lumbar vertebrae, although the distinction is clearest in the third, fourth and fifth lumbars.

success rate for *Bison*	19/25 = 76.00%
success rate for *Bos*	9/13 = 69.23%

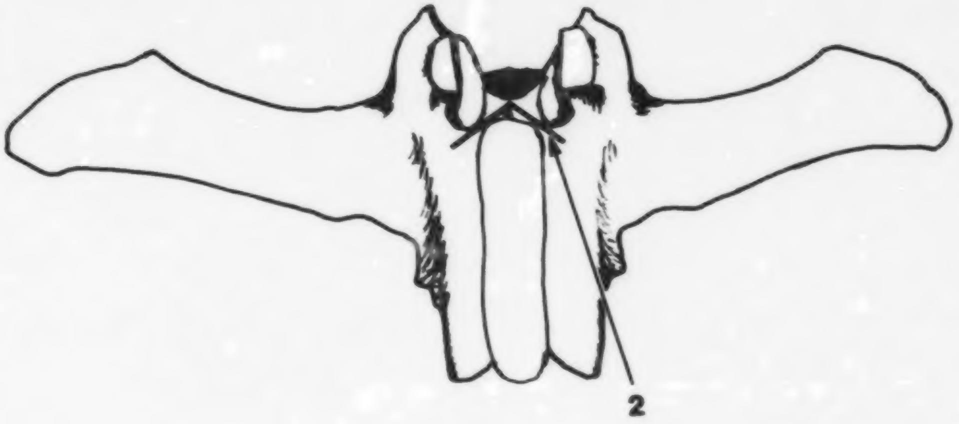
Character #2: posterior edge of articular facet	Aspect 1	Aspect 2	Aspect 3
	behind spine	even spine	intermediate
No. of *Bison*	19/25	3/25	3/25
No. of *Bos*	2/13	9/13	2/13
Preference Factor *Bison*	4.16	0.19	0.74
Preference Factor *Bos*	0.24	5.14	1.34

(3)* The transverse processes in *Bison* tend to taper towards the ends. In *Bos* the antero-posterior depth is nearly uniform along the entire length of these processes. (Not illustrated)

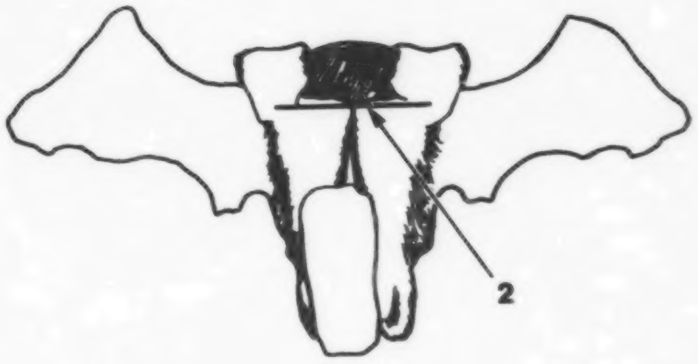
success rate for *Bison*	** 3/8 = 37.50%
success rate for *Bos*	** 5/8 = 62.50%

Character #3: transverse process	Aspect 1	Aspect 2	Aspect 3
	tapered	uniform	intermediate
No. of *Bison*	3/8	0/8	5/8
No. of *Bos*	2/8	5/8	1/8
Preference Factor *Bison*	1.40	0.07	3.73
Preference Factor *Bos*	0.71	14.93	0.27

** Note that sample sizes are very small for this character.



BISON



BOS

Figure 22. First Lumbar Vertebra, Dorsal View

LUMBAR VERTEBRAE

Fig. 22. Dorsal View

(4) The anterior portion of the neural arch is narrower and almost V-shaped in *Bison*, more like a broad U in *Bos*. This distinction applies to the first three lumbar vertebrae.

success rate for *Bison*	18/23 = 78.26%
success rate for *Bos*	5/13 = 38.46%

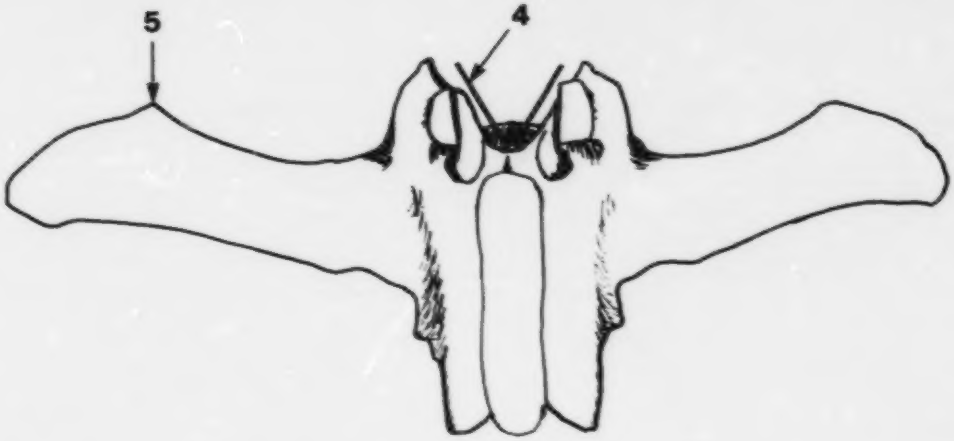
Character #4: anterior neural arch	Aspect 1	Aspect 2	Aspect 3
	V-shaped	U-shaped	intermediate
No. of *Bison*	18/23	1/23	4/23
No. of *Bos*	5/13	5/13	3/13
Preference Factor *Bison*	1.93	0.15	0.74
Preference Factor *Bos*	0.52	6.50	1.35

(5)* In *Bison* the transverse process of the first lumbar vertebra usually has a small pointed projection or spike on the anterior margin. In *Bos* this projection is less pronounced or absent. (Note: this does not refer to the overall deltoid shape of the transverse process of the first lumbar in *Bos*, only to the small spike on the anterior margin in *Bison*).

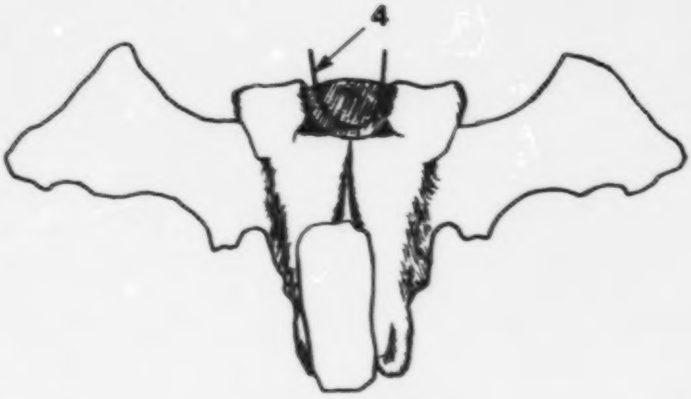
success rate for *Bison*	** 4/8 = 50.00%
success rate for *Bos*	** 4/6 = 75.00%

Character #5: first lumbar: small spike	Aspect 1	Aspect 2	Aspect 3
	present	absent	intermediate
No. of *Bison*	4/8	3/8	1/8
No. of *Bos*	2/6	4/6	0/6
Preference Factor *Bison*	1.38	0.59	3.06
Preference Factor *Bos*	0.72	1.68	0.33

** Note that sample sizes are very small for this character.



BISON



BOS

Figure 22. First Lumbar Vertebra, Dorsal View

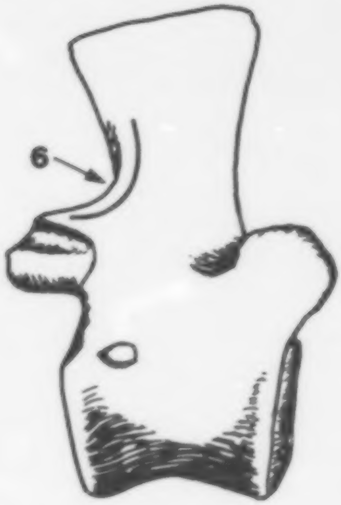
LUMBAR VERTEBRAE

Fig. 23. Lateral View

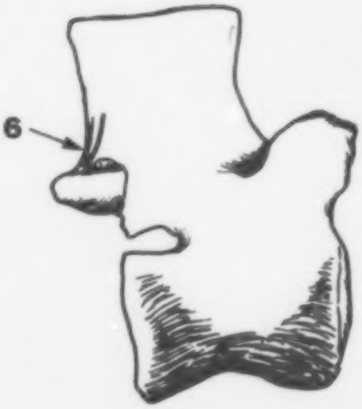
(6) The posterior edge of the neural spine branches down in a long strong ridge separating it from the posterior articular process to a markedly greater extent in *Bison* than in *Bos*. This applies to all lumbar vertebrae, although there is usually no ridge in *Bison* fifth lumbars.

success rate for *Bison*	25/25 = 100.0%
success rate for *Bos*	11/13 = 84.62%

Character #6: separation by strong ridge	Aspect 1	Aspect 2	Aspect 3
	greater	lesser	intermediate
No. of *Bison*	25/25	0/25	0/25
No. of *Bos*	2/13	11/13	0/13
Preference Factor *Bison*	5.44	0.02	0.53
Preference Factor *Bos*	0.18	59.04	1.89



BISON



BOS

Figure 23. Second Lumbar Vertebra, Lateral View
(transverse process omitted)

LUMBAR VERTEBRAE

Fig. 24. Posterior View

(7) The depression at the base of the posterior border of the neural spine is deep in *Bison*, very shallow in *Bos*. This distinction applies to the first four lumbar vertebrae.

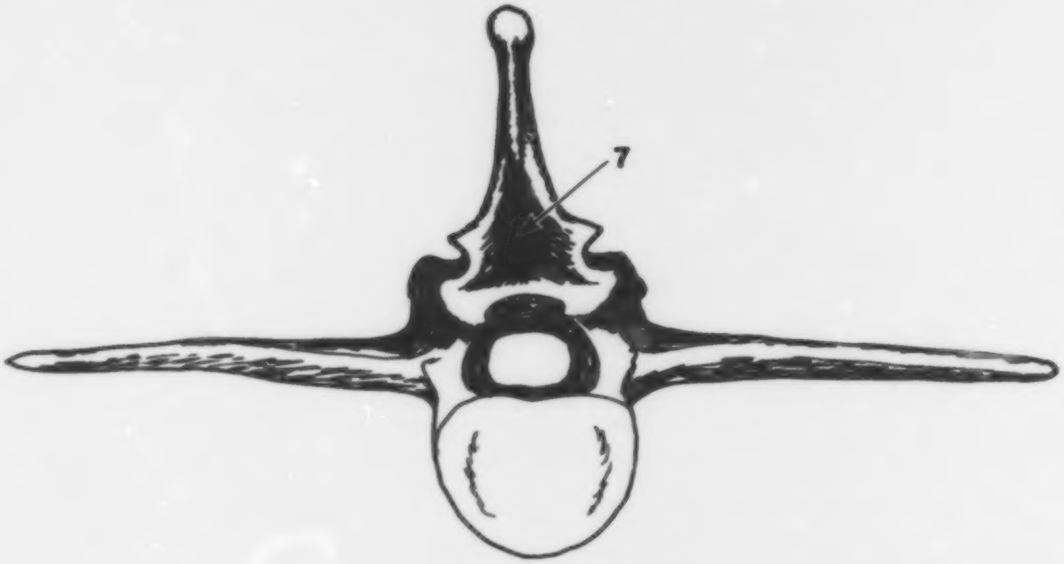
success rate for *Bison*	22/25 = 88.00%
success rate for *Bos*	12/13 = 92.31%

Character #7: depression at base of neural spine	Aspect 1	Aspect 2	Aspect 3
	deep	shallow	intermediate
No. of *Bison*	22/25	0/25	3/25
No. of *Bos*	1/13	12/13	0/13
Preference Factor *Bison*	8.09	0.02	5.02
Preference Factor *Bos*	0.12	64.18	0.20

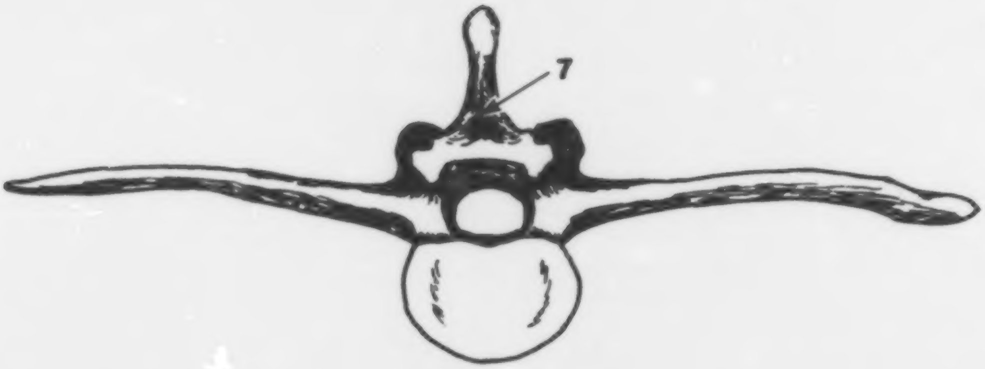
(8) The dorsal surface of the transverse process has a slight dip along its length in *Bos*, but is flat or slightly concave in *Bison*. This distinction, which is most obvious about halfway along the transverse process, is often more apparent to the touch than to the eye. (Shown but not marked)

success rate for *Bison*	20/25 = 80.00%
success rate for *Bos*	12/13 = 92.31%

Character #8: dorsal surface of transverse process	Aspect 1	Aspect 2	Aspect 3
	flat	slight dip	intermediate
No. of *Bison*	20/25	3/25	2/25
No. of *Bos*	0/13	12/13	1/13
Preference Factor *Bison*	29.49	0.15	0.89
Preference Factor *Bos*	0.03	6.77	1.12



BISON



BOS

Figure 24. Second Lumbar Vertebra, Posterior View

SACRUM

Fig. 25. Anterior View

(1) The anterior end of the vertebral foramen forms a high narrow triangle in *Bison*, a lower wider triangle in *Bos*.

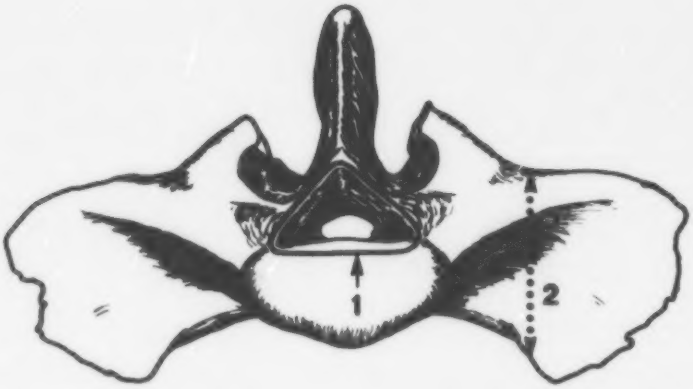
success rate for *Bison*	16/24 = 66.67%
success rate for *Bos*	10/14 = 71.43%

Character #1: anterior end of vertebral foramen	Aspect 1	Aspect 2	Aspect 3
	high, narrow	low, wide	intermediate
No. of *Bison*	16/24	4/24	4/24
No. of *Bos*	3/14	10/14	1/14
Preference Factor *Bison*	2.80	0.25	1.81
Preference Factor *Bos*	0.36	3.95	0.55

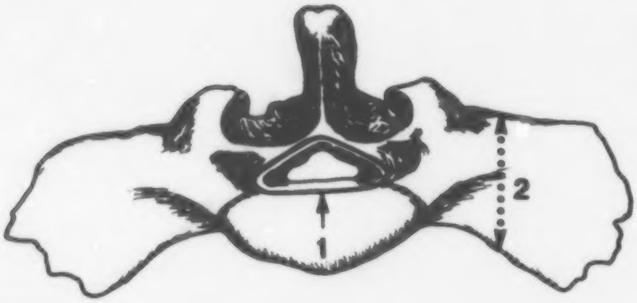
(2) The "wings" appear deeper in *Bison*, giving a rather squat appearance. In *Bos* they appear narrower. This distinction is noticeable just lateral to the anterior articular processes.

success rate for *Bison*	21/25 = 84.00%
success rate for *Bos*	12/14 = 85.71%

Character #2: appearance of wings	Aspect 1	Aspect 2	Aspect 3
	deeper	narrower	intermediate
No. of *Bison*	21/25	3/25	1/25
No. of *Bos*	2/14	12/14	0/14
Preference Factor *Bison*	4.92	0.16	2.27
Preference Factor *Bos*	0.20	6.30	0.44



BISON



BOS

Figure 25. Sacrum, Anterior View

SACRUM

Fig. 25. Anterior View

(3)* Olsen (1960) described the anterior end of the body as more ovaloid in *Bos*, more triangular in *Bison*. We initially found just the opposite (see character 4 below).

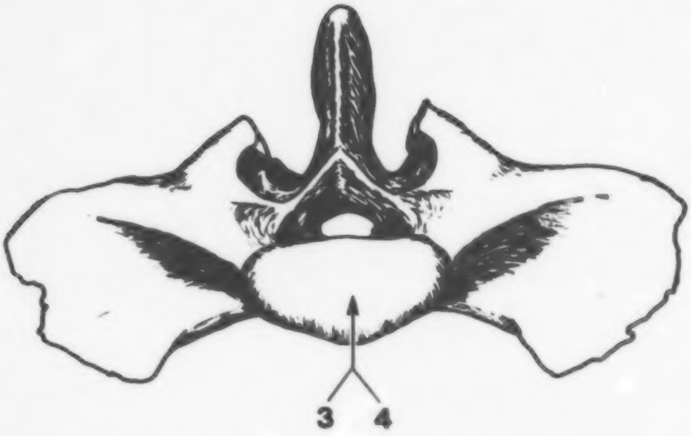
success rate for *Bison*	7/23 = 30.43%
success rate for *Bos*	5/10 = 50.00%

Character #3: anterior end of body	Aspect 1	Aspect 2	Aspect 3
	triangular	ovaloid	intermediate
No. of *Bison*	7/23	12/23	4/23
No. of *Bos*	3/10	5/10	2/10
Preference Factor *Bison*	0.96	1.02	0.81
Preference Factor *Bos*	1.04	0.98	1.24

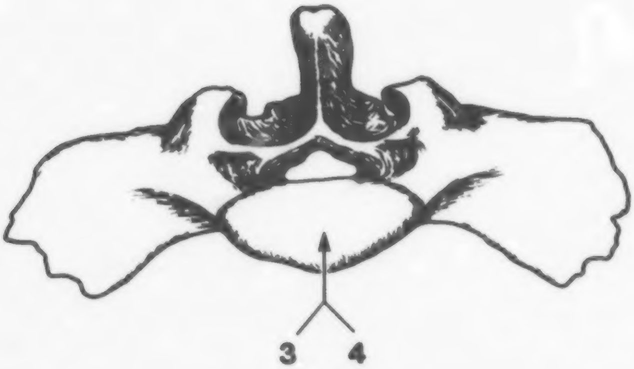
(4) Early in our study, we felt that the articular surface of the body is rounded and oval in *Bison*, more triangular in *Bos*, with the apex of the triangle to the ventral side. Obviously characters 3 and 4 are subject to a great deal of individual variation and are quite useless for separating the species.

success rate for *Bison*	12/23 = 52.17%
success rate for *Bos*	3/10 = 30.00%

Character #4: articular surface of body	Aspect 1	Aspect 2	Aspect 3
	oval	triangular	intermediate
No. of *Bison*	12/23	7/23	4/23
No. of *Bos*	5/10	3/10	2/10
Preference Factor *Bison*	1.02	0.96	0.81
Preference Factor *Bos*	0.98	1.04	1.24



BISON



BOS

Figure 25. Sacrum, Anterior View

SACRUM

Fig. 25. Anterior View

(5) The ridge along anterior margin of the neural spine is divided higher up in *Bison* than in *Bos*. This division occurs near the top of the anterior articular process in *Bison*, much nearer the bottom of this process in *Bos*.

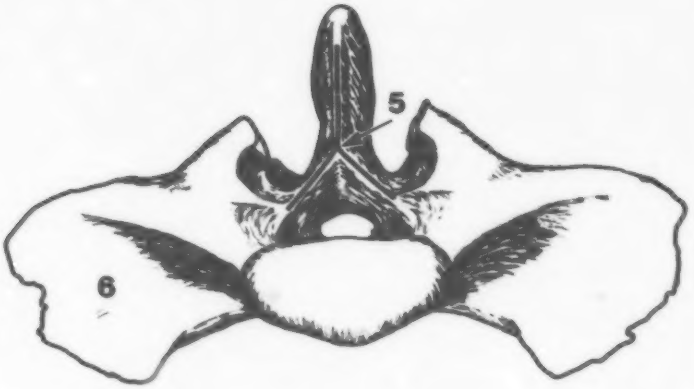
success rate for *Bison*	23/24 = 95.83%
success rate for *Bos*	11/12 = 91.67%

Character #5: division of ridge on neural spine	Aspect 1	Aspect 2	Aspect 3
	near top	near bottom	intermediate
No. of *Bison*	23/24	1/24	0/24
No. of *Bos*	0/12	11/12	1/12
Preference Factor *Bison*	32.58	0.07	0.13
Preference Factor *Bos*	0.03	15.32	7.84

(6) The antero-ventral surface of the wings is slightly concave in *Bison*, slightly convex in *Bos*. This distinction is more apparent to the touch than to the eye.

success rate for *Bison*	20/23 = 86.96%
success rate for *Bos*	11/12 = 91.67%

Character #6: antero-ventral surface of wings	Aspect 1	Aspect 2	Aspect 3
	concave	convex	intermediate
No. of *Bison*	20/23	2/23	1/23
No. of *Bos*	0/12	11/12	1/12
Preference Factor *Bison*	29.63	0.11	0.53
Preference Factor *Bos*	0.03	8.71	1.88



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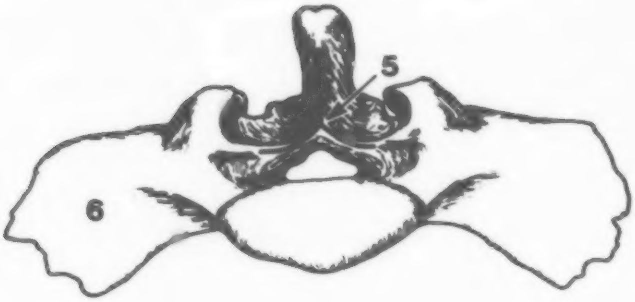


BOS

Figure 25. Sacrum, Anterior View

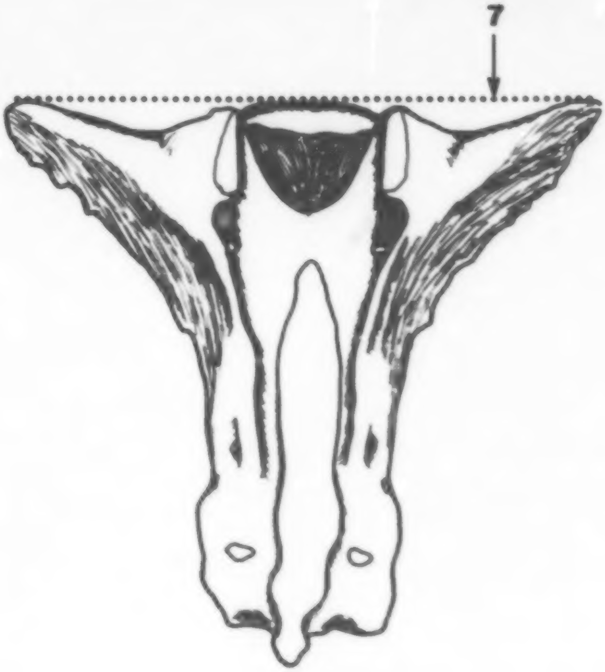
SACRUM

Fig. 26. Dorsal View

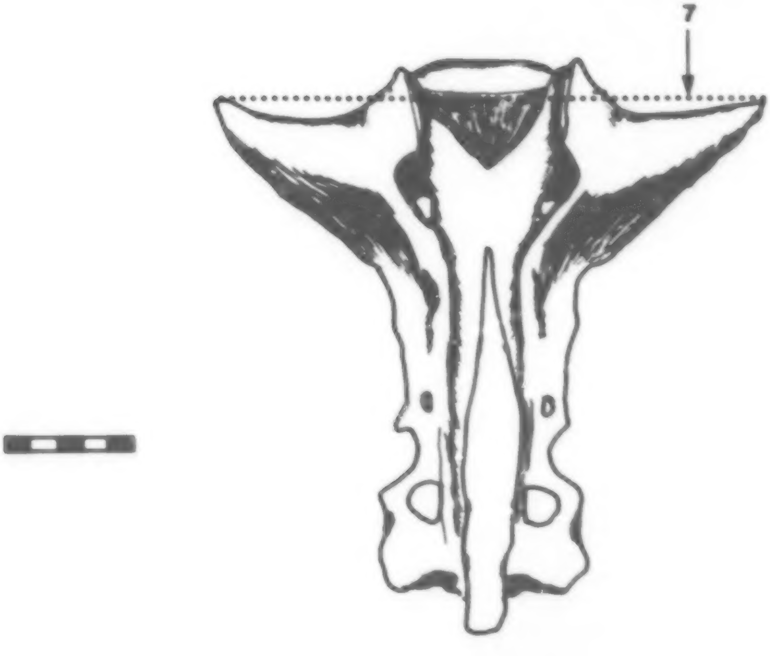
(7)* The wings are inclined forwards more sharply in *Bison* so that they are almost level with the anterior end of the body. (A ruler held across the anterior end of the first sacral vertebra almost touches the wings).

success rate for *Bison*	20/24 = 83.33%
success rate for *Bos*	10/12 = 83.33%

Character #7: forward inclination of wings	Aspect 1	Aspect 2	Aspect 3
	ruler touches wings	ruler forward of wings	intermediate
No. of *Bison*	20/24	3/24	1/24
No. of *Bos*	1/12	10/12	1/12
Preference Factor *Bison*	7.11	0.17	0.51
Preference Factor *Bos*	0.14	5.90	1.96



BISON



BOS

Figure 26. Sacrum, Dorsal View

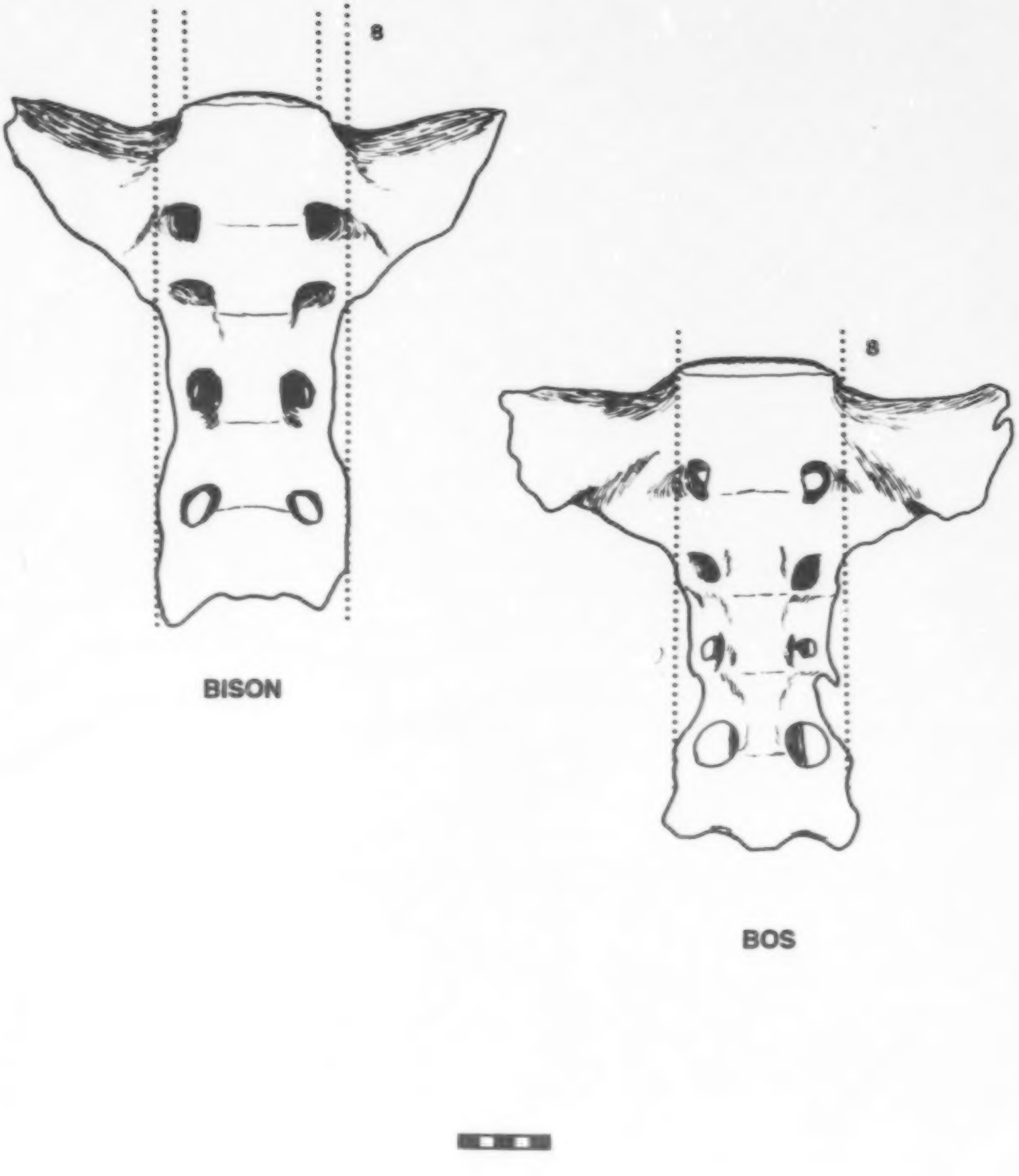
SACRUM

Fig. 27. Ventral View

(8)* In *Bos* the lateral borders of the anterior epiphysis of the first sacral vertebra are in line with the parallel margins of the main body of the sacrum. In *Bison* the lateral extension of the anterior epiphysis is considerably inside the parallel margins of the main body of the sacrum.

success rate for *Bison*	12/23 = 52.17%
success rate for *Bos*	7/10 = 70.00%

Character #8: lateral borders of anterior epiphysis	Aspect 1	Aspect 2	Aspect 3
	inside body margins	in line with body margins	intermediate
No. of *Bison*	12/23	7/23	4/23
No. of *Bos*	3/10	7/10	0/10
Preference Factor *Bison*	1.60	0.45	5.45
Preference Factor *Bos*	0.62	2.24	0.18



BISON

BOS

Figure 27. Sacrum, Ventral View

SCAPULA

Fig. 28. Medial View

(1) Adult *Bison* have a deep channel or groove between the coracoid process and the margin of the glenoid cavity. This is not as apparent in *Bos*.

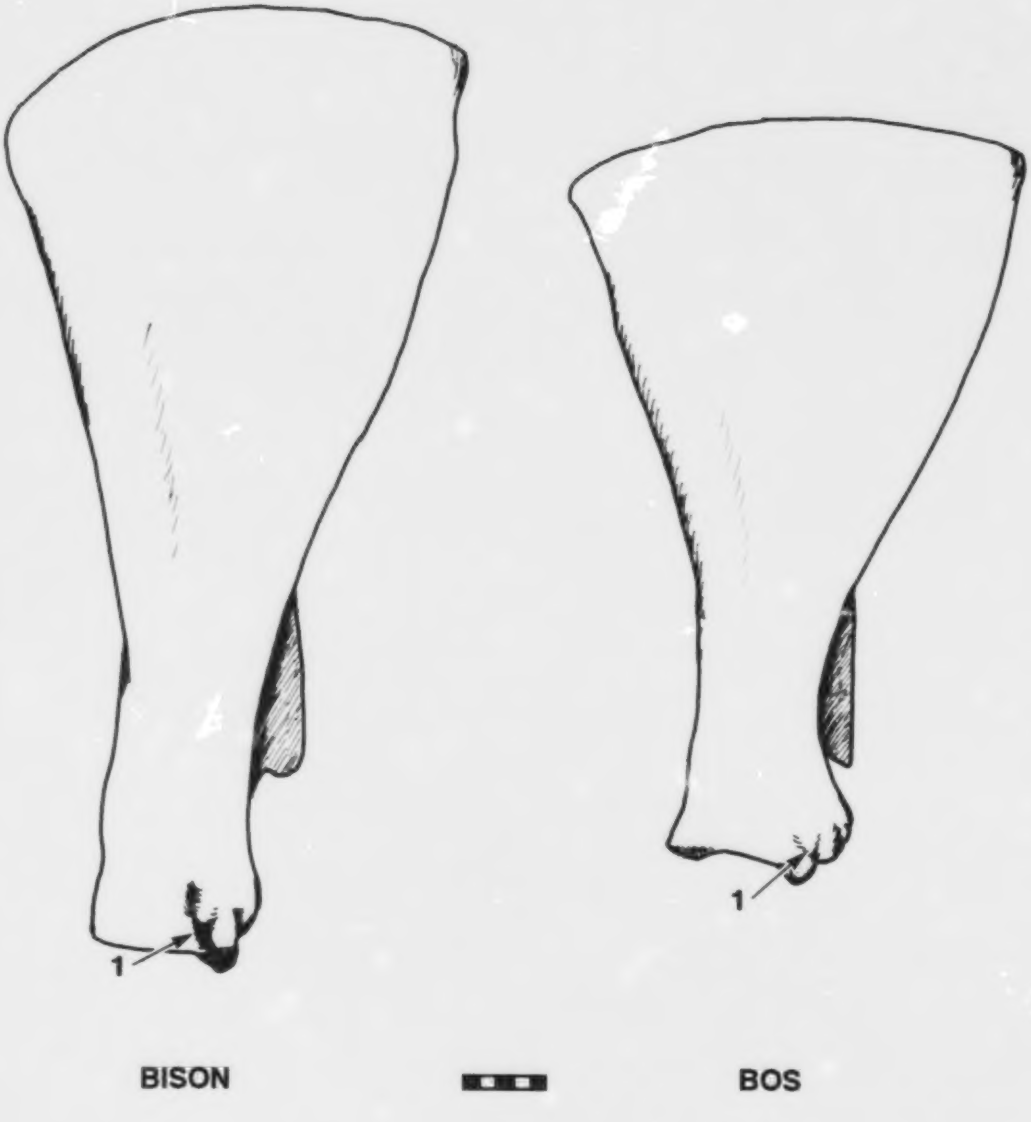
success rate for *Bison*	23/27 = 85.19%
success rate for *Bos*	13/14 = 92.86%

Character #1: channel or groove near glenoid cavity	Aspect 1	Aspect 2	Aspect 3
	deep channel	channel absent	slight pit
No. of *Bison*	23/27	1/27	3/27
No. of *Bos*	0/14	13/14	1/14
Preference Factor *Bison*	33.67	0.06	1.25
Preference Factor *Bos*	0.03	17.40	0.80

(2)* The general overall shape is longer and thinner in *Bison*, shorter and more flared in *Bos*.

success rate for *Bison*	26/26 = 100.0%
success rate for *Bos*	13/15 = 86.67%

Character #2: overall shape of scapula	Aspect 1	Aspect 2	Aspect 3
	long and thin	more flared	intermediate
No. of *Bison*	26/26	0/26	0/26
No. of *Bos*	2/15	13/15	0/15
Preference Factor *Bison*	6.24	0.02	0.58
Preference Factor *Bos*	0.16	62.73	1.71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BISON
BOS

Figure 28. Scapula, Medial View

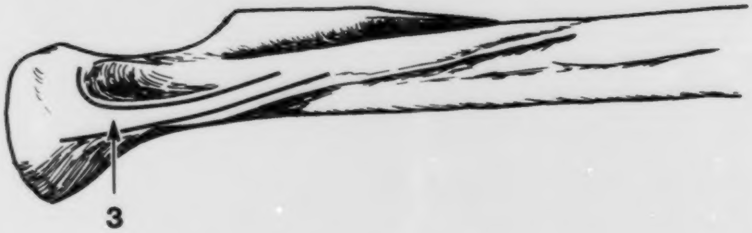
SCAPULA

Fig. 29. Posterior Border

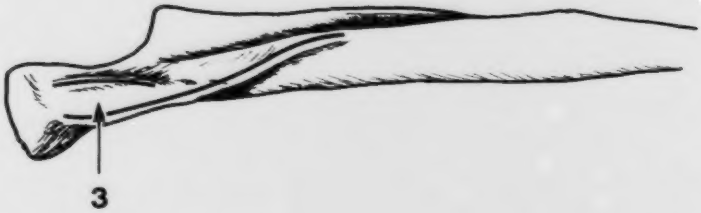
(3) The area immediately dorsal to the glenoid cavity and bordered by the mid-neck ridge and the posterior margin is noticeably thinned and flattened in *Bison*, due to the deep, trough-like, roughened origin of the infraspinatus muscle. In *Bos* this surface is more steeply angled, with the scar for the attachment of the infraspinatus muscle a prominent surface feature on the same plane, as opposed to its pit-like location in *Bison*.

success rate for *Bison*	27/27 = 100.0%
success rate for *Bos*	10/15 = 66.67%

Character #3: area dorsal to glenoid	Aspect 1	Aspect 2	Aspect 3
	thin and flat	angled	intermediate
No. of *Bison*	27/27	0/27	0/27
No. of *Bos*	5/15	10/15	0/15
Preference Factor *Bison*	2.82	0.02	0.56
Preference Factor *Bos*	0.35	50.63	1.77



BISON



BOS

Figure 29. Posterior Border of Distal Scapula

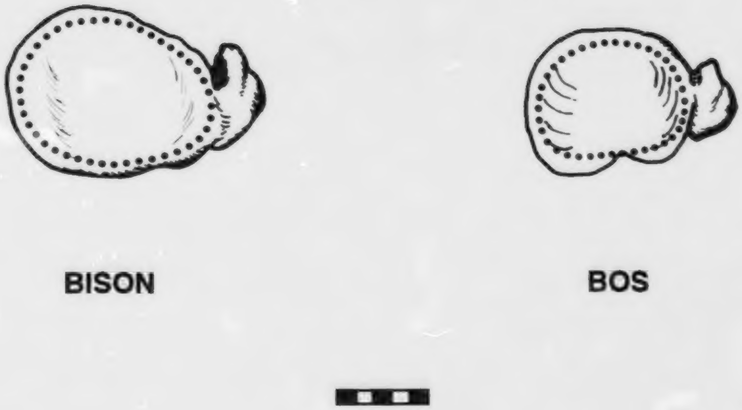
SCAPULA

Fig. 30. Glenoid Cavity

(4)* The articular surface of the glenoid cavity is nearly round in *Bos*, more oval in *Bison*.

success rate for *Bison*	23/27 = 85.19%
success rate for *Bos*	11/14 = 78.57%

Character #4: shape of glenoid	Aspect 1	Aspect 2	Aspect 3
	oval	round	intermediate
No. of *Bison*	23/27	4/27	0/27
No. of *Bos*	2/14	11/14	1/14
Preference Factor *Bison*	4.99	0.21	0.13
Preference Factor *Bos*	0.20	4.86	7.59



BISON

BOS

Figure 30. Glenoid Cavity of Scapula

HUMERUS

Fig. 31. Anterior View

(1)* In *Bos* the medial point of the lateral tuberosity overhangs the bicipital groove. *Bison* forms an obtuse angle with no noticeable overhang.

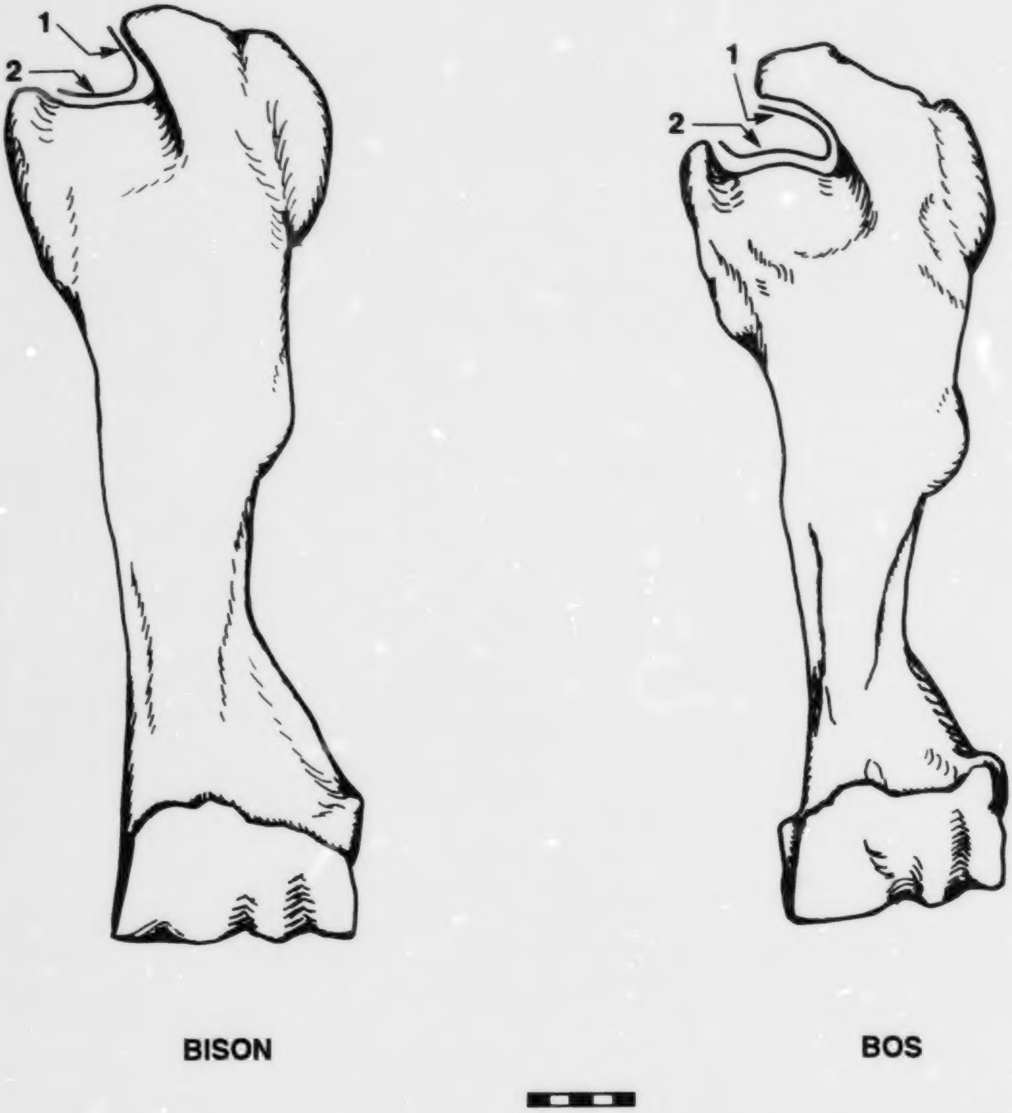
success rate for *Bison*	19/28 = 67.86%
success rate for *Bos*	14/14 = 100.0%

Character #1: bicipital overhang	Aspect 1	Aspect 2	Aspect 3
	absent	present	intermediate
No. of *Bison*	19/28	5/28	4/28
No. of *Bos*	0/14	14/14	0/14
Preference Factor *Bison*	26.96	0.19	6.21
Preference Factor *Bos*	0.04	5.19	0.16

(2)* The floor of the bicipital groove in *Bos* has a swelling, whereas in *Bison* it slopes evenly.

success rate for *Bison*	10/25 = 40.00%
success rate for *Bos*	13/14 = 92.86%

Character #2: floor of bicipital groove	Aspect 1	Aspect 2	Aspect 3
	with swelling	even slope	intermediate
No. of *Bison*	10/25	9/25	6/25
No. of *Bos*	1/14	13/14	0/14
Preference Factor *Bison*	4.06	0.40	10.04
Preference Factor *Bos*	0.25	2.50	0.10



BISON

BOS

Figure 31. Humerus, Anterior View

HUMERUS

Fig. 31. Anterior View

(3) The distal condyles project medially in *Bos*, but form nearly a straight line with the shaft in *Bison*.

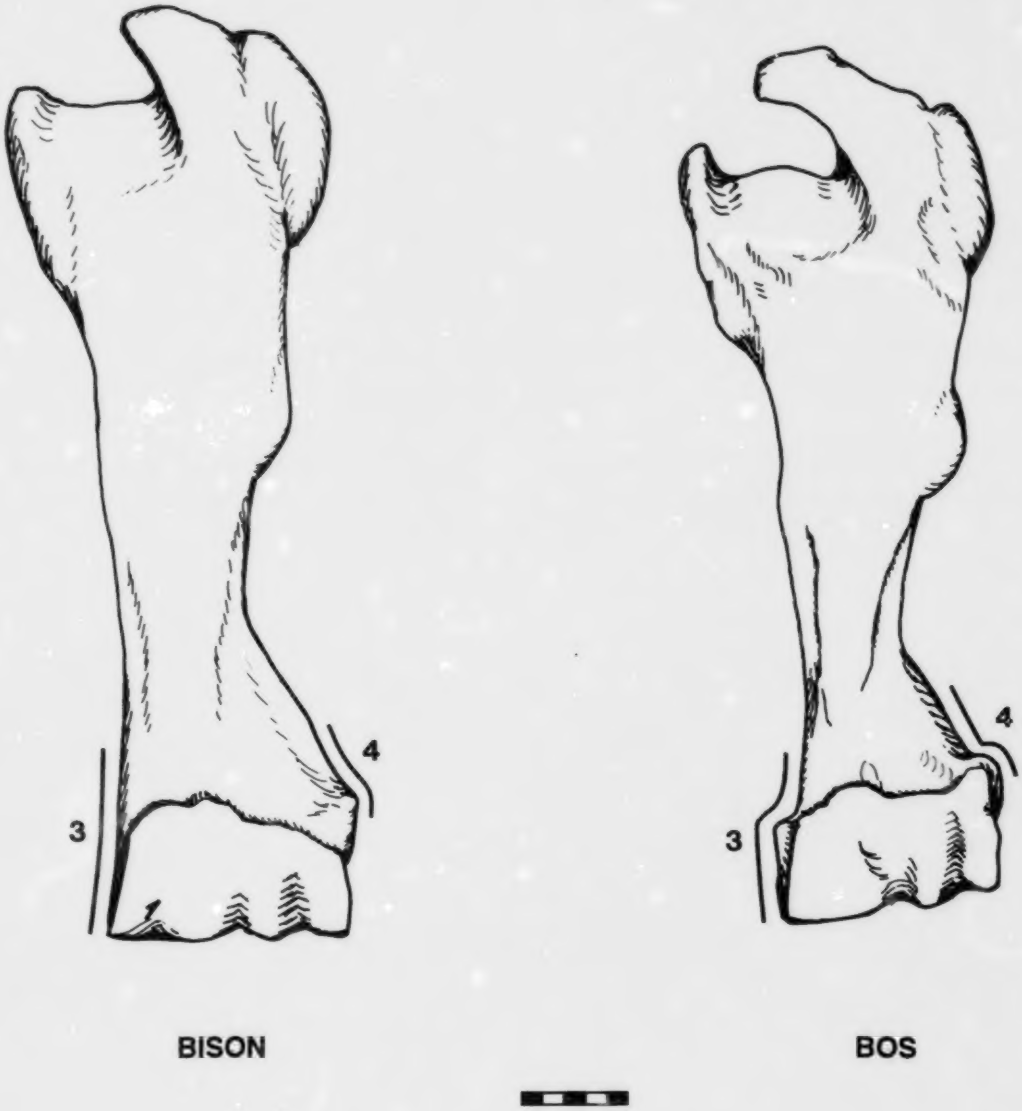
success rate for *Bison*	26/28 = 92.86%
success rate for *Bos*	13/13 = 100.0%

Character #3: distal condyles	Aspect 1	Aspect 2	Aspect 3
	straight line with shaft	project medially	intermediate
No. of *Bison*	26/28	1/28	1/28
No. of *Bos*	0/13	13/13	0/13
Preference Factor *Bison*	34.11	0.05	1.89
Preference Factor *Bos*	0.03	19.37	0.53

(4) The lateral epicondyloid crest is more pronounced in *Bison*. As a result, the lateral condyle appears to project more in *Bos* than in *Bison*.

success rate for *Bison*	27/28 = 96.43%
success rate for *Bos*	13/13 = 100.0%

Character #4: lateral condyle projection	Aspect 1	Aspect 2	Aspect 3
	slight	greater	intermediate
No. of *Bison*	27/28	1/28	0/28
No. of *Bos*	0/13	13/13	0/13
Preference Factor *Bison*	35.40	0.05	0.47
Preference Factor *Bos*	0.03	19.37	2.11



BISON

BOS

Figure 31. Humerus, Anterior View

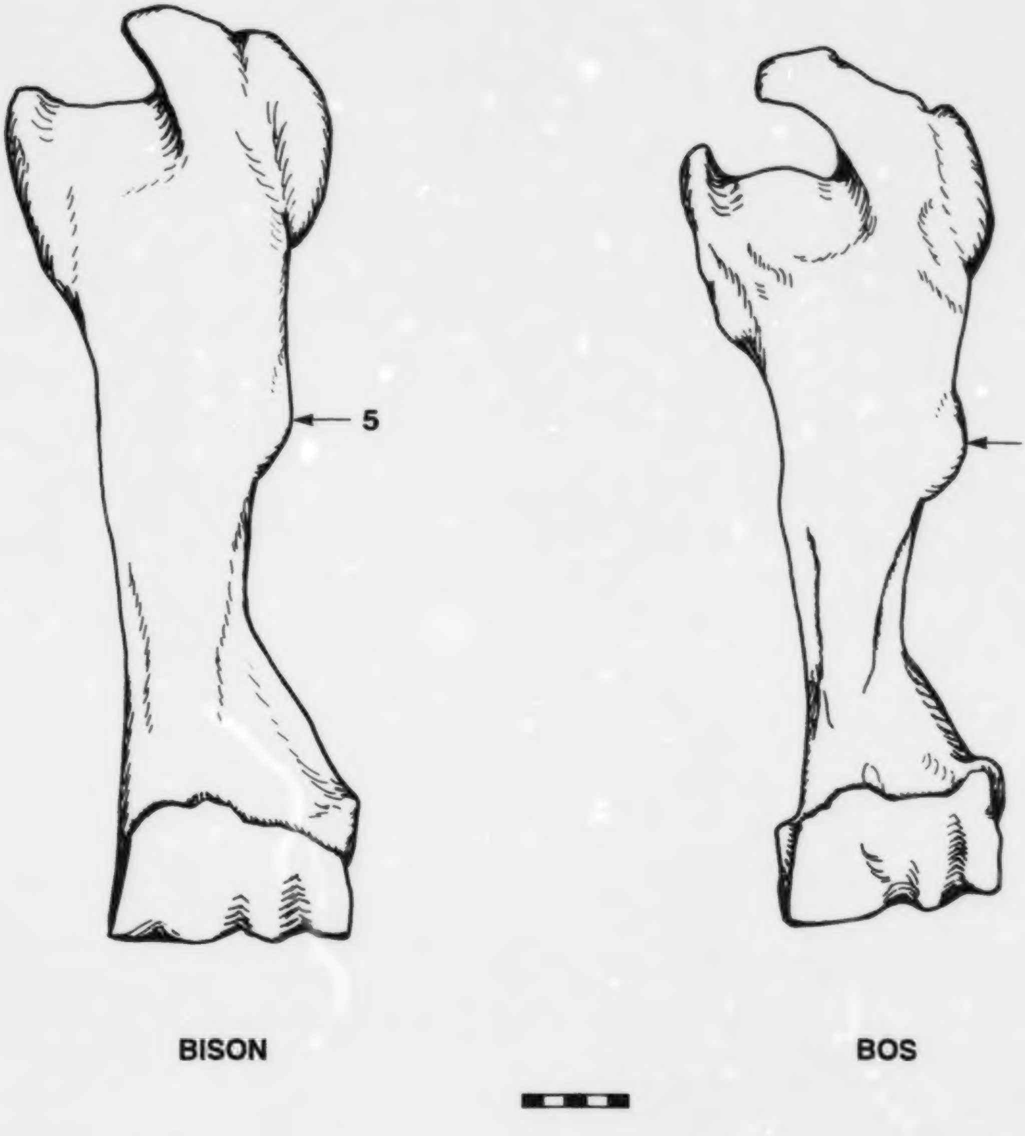
HUMERUS

Fig. 31. Anterior View

(5) *Bos* has a well-developed midshaft lateral-hooking deltoid tuberosity. In *Bison* this appears more as a simple raised scar or roughened bump. See also Fig. 32.

success rate for *Bison*	13/28 = 46.43%
success rate for *Bos*	9/13 = 69.23%

Character #5: deltoid tuberosity	Aspect 1	Aspect 2	Aspect 3
	simple scar	well-developed	intermediate
No. of *Bison*	13/28	10/28	5/28
No. of *Bos*	2/13	9/13	2/13
Preference Factor *Bison*	2.57	0.52	1.05
Preference Factor *Bos*	0.39	1.91	0.95



BISON

BOS

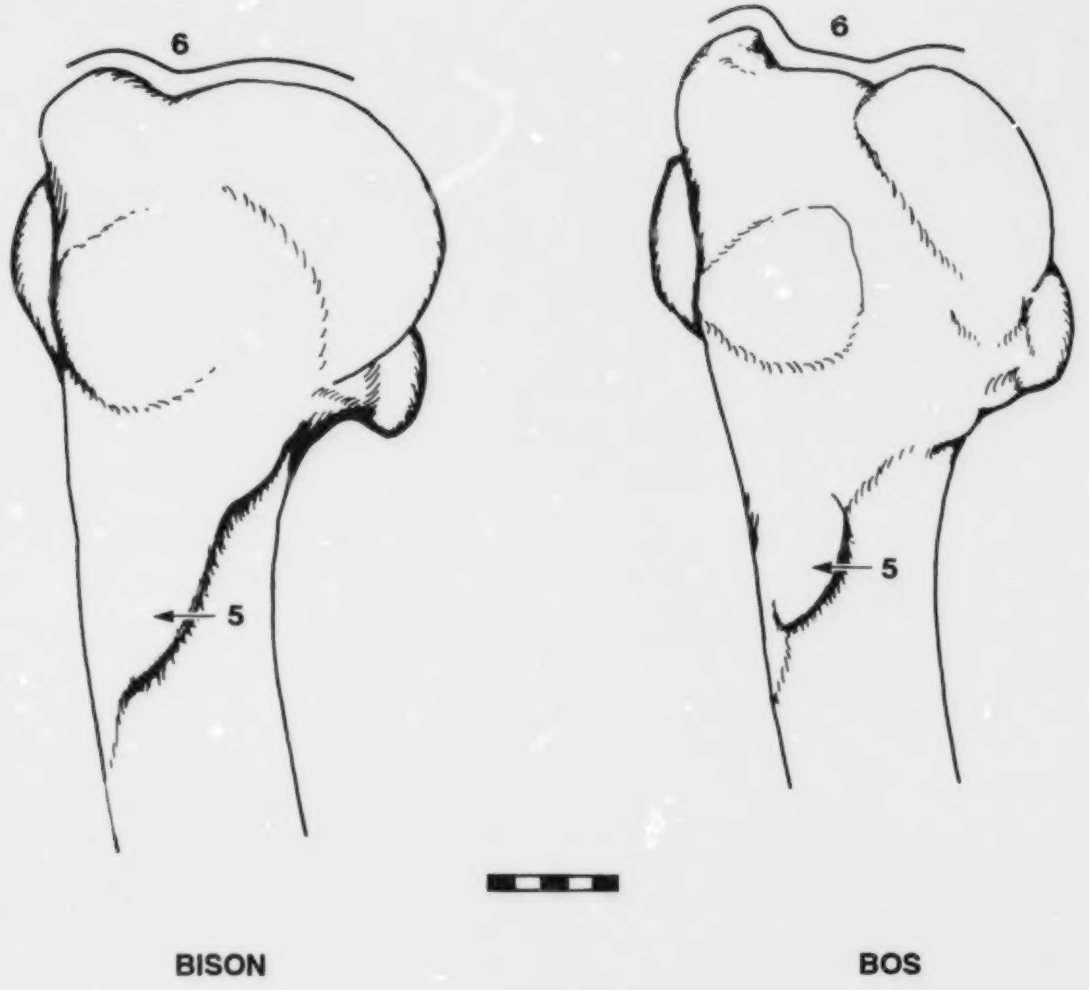
Figure 31. Humerus, Anterior View

Fig. 32. Proximal Humerus, Three-Quarters Lateral View

(6)* The lateral tuberosity of *Bison* has a single deep notch, whereas in *Bos* the tuberosity is not as deeply notched or has two lesser grooves.

success rate for *Bison*	26/28 = 92.86%
success rate for *Bos*	12/14 = 85.71%

Character #6: notch in lateral tuberosity	Aspect 1	Aspect 2	Aspect 3
	deep, single	shallow	intermediate
No. of *Bison*	26/28	1/28	1/28
No. of *Bos*	2/14	12/14	0/14
Preference Factor *Bison*	5.43	0.06	2.03
Preference Factor *Bos*	0.18	16.69	0.49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BISON
BOS

Figure 32. Proximal Humerus, Three-Quarters Lateral View

HUMERUS

Fig. 33. Distal Humerus, Lateral View

(7)* *Bison* has a continuous gentle curve along the ridge connecting the main shaft with the lateral condyle. This ridge in *Bos* has a break or angle at the junction with the main shaft.

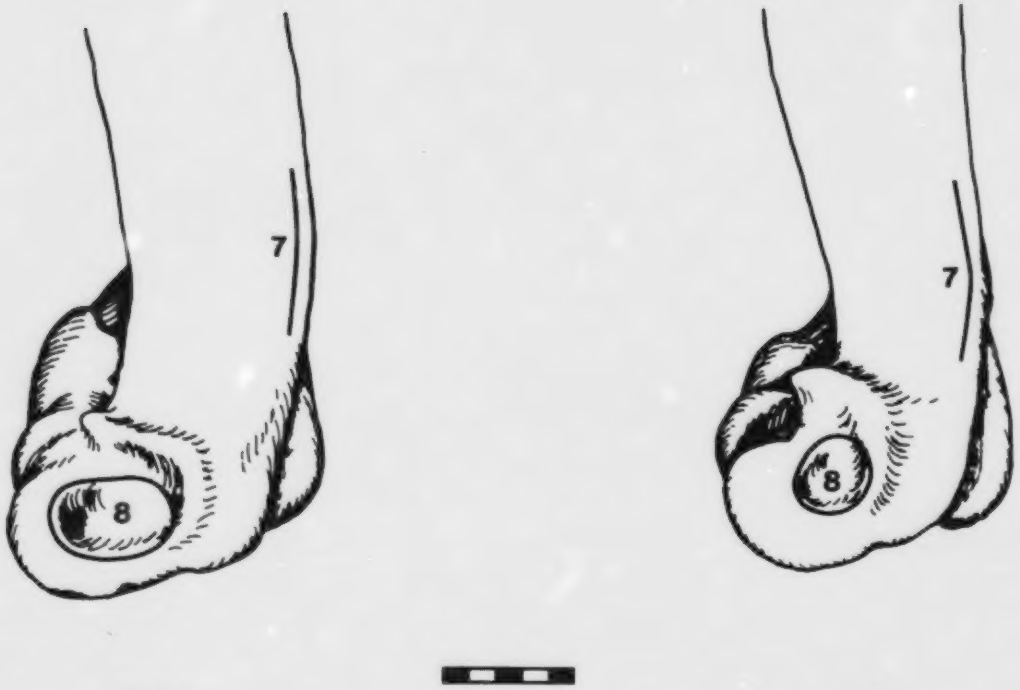
success rate for *Bison*	24/28 = 85.71%
success rate for *Bos*	10/13 = 76.92%

Character #7: ridge from shaft to lateral condyle	Aspect 1	Aspect 2	Aspect 3
	continuous	break/angle	intermediate
No. of *Bison*	24/28	1/28	3/28
No. of *Bos*	2/13	10/13	1/13
Preference Factor *Bison*	4.67	0.07	1.12
Preference Factor *Bos*	0.21	15.06	0.89

(8)* The fossa for muscle attachment on the lateral condyle (which is actually the depression for attachment of the lateral ligament) is larger, more irregularly shaped in *Bison* compared with the nearly round pit in *Bos*.

success rate for *Bison*	27/28 = 96.43%
success rate for *Bos*	12/13 = 92.31%

Character #8: fossa on lateral condyle	Aspect 1	Aspect 2	Aspect 3
	irregular	round pit	intermediate
No. of *Bison*	27/28	1/28	0/28
No. of *Bos*	0/13	12/13	1/13
Preference Factor *Bison*	35.40	0.06	0.12
Preference Factor *Bos*	0.03	17.93	8.45



BISON

BOS

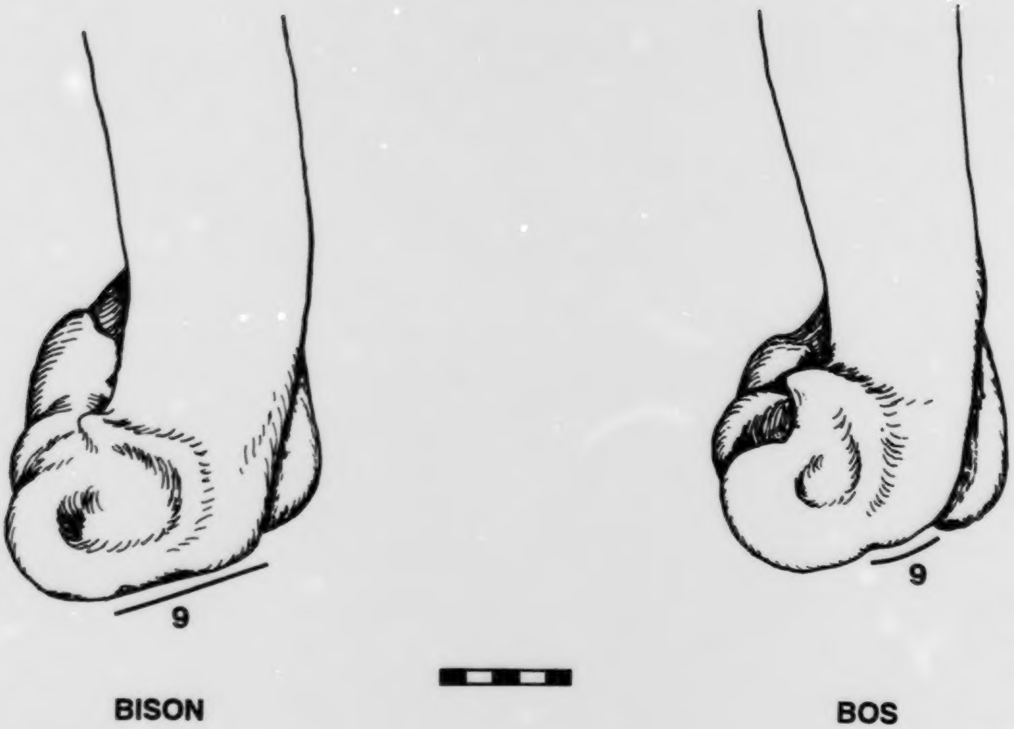
Figure 33. Distal Humerus, Lateral View

Fig. 33. Distal Humerus, Lateral View

(9) In lateral view the distal margin of the lateral epicondyle in *Bison* ascends in a straight line from a point below the depression for the attachment for the lateral ligament. In *Bos* the margin is shorter and more curved, originating from a point below the lateral epicondylar crest.

success rate for *Bison*	26/28 = 92.86%
success rate for *Bos*	12/12 = 100.0%

Character #9: origin of lateral epicondyle	Aspect 1	Aspect 2	Aspect 3
	below fossa	below crest	intermediate
No. of *Bison*	26/28	1/28	1/28
No. of *Bos*	0/12	12/12	0/12
Preference Factor *Bison*	31.59	0.05	1.75
Preference Factor *Bos*	0.03	19.37	0.57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BISON
BOS

Figure 33. Distal Humerus, Lateral View

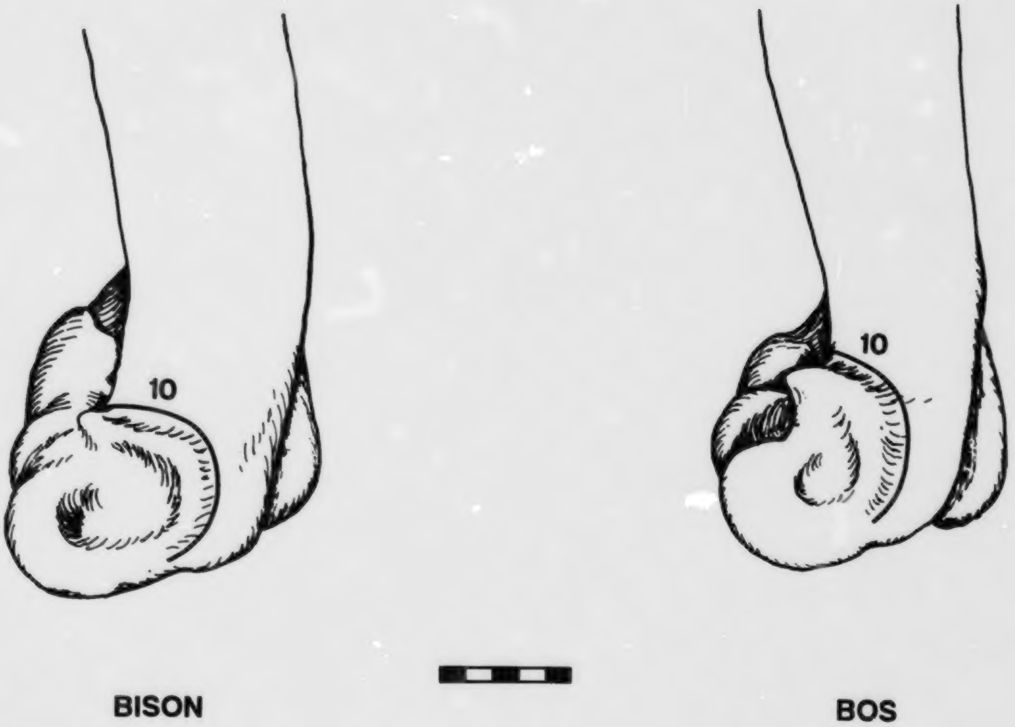
HUMERUS

Fig. 33. Distal Humerus, Lateral View

(10) Note the difference in the shape of the ridge which defines the depression for the attachment of the lateral ligament. In *Bison* this ridge extends posteriorly from the capitulum, then turns sharply downwards to form a broad U shape. In *Bos* the ridge is less strongly curved posteriorly, forming a crescent rather than a U.

success rate for *Bison*	26/28 = 92.86%
success rate for *Bos*	11/12 = 91.67%

Character #10: shape of ridge	Aspect 1	Aspect 2	Aspect 3
	broad U	crescent	intermediate
No. of *Bison*	26/28	0/28	2/28
No. of *Bos*	1/12	11/12	0/12
Preference Factor *Bison*	7.90	0.01	2.96
Preference Factor *Bos*	0.13	71.27	0.34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BISON
BOS

Figure 33. Distal Humerus, Lateral View

HUMERUS

Fig. 34. Distal Humerus, Medial View

(11)* The ridge of the medial epicondyle forms almost a right angle in *Bison*, projects much lower in *Bos*.

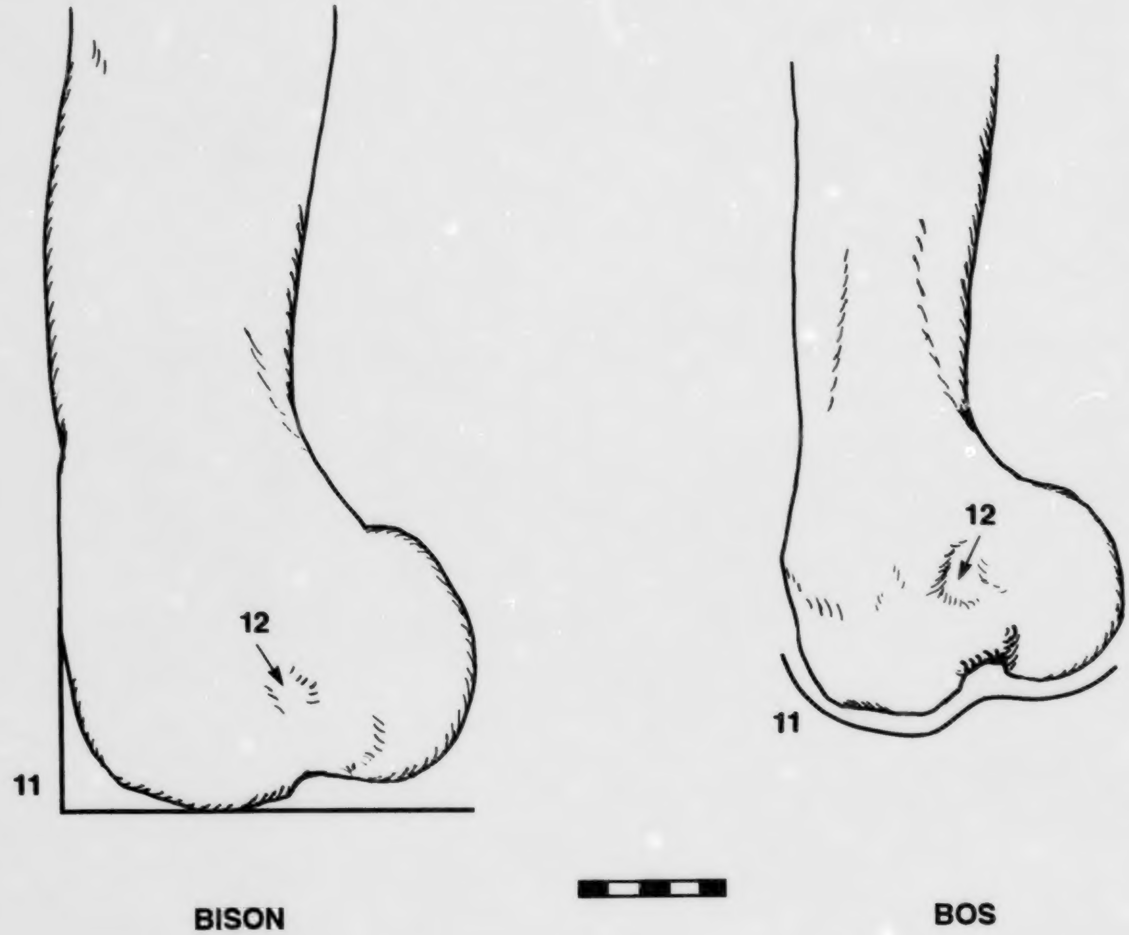
success rate for *Bison*	17/28 = 60.71%
success rate for *Bos*	13/14 = 92.86%

Character #11: ridge of medial epicondyle	Aspect 1	Aspect 2	Aspect 3
	right angle	projects lower	intermediate
No. of *Bison*	17/28	10/28	1/28
No. of *Bos*	1/14	13/14	0/14
Preference Factor *Bison*	6.05	0.40	2.03
Preference Factor *Bos*	0.17	2.53	0.49

(12) The attachment for the pronator teres is a pronounced bump in *Bos*, just a slightly raised area in *Bison*.

success rate for *Bison*	26/28 = 92.86%
success rate for *Bos*	12/14 = 85.71%

Character #12: attachment for pronator teres	Aspect 1	Aspect 2	Aspect 3
	pronounced bump	slightly raised area	intermediate
No. of *Bison*	1/28	26/28	1/28
No. of *Bos*	12/14	1/14	1/14
Preference Factor *Bison*	0.06	9.16	0.51
Preference Factor *Bos*	16.69	0.11	1.97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BISON
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BOS

Figure 34. Distal Humerus, Medial View

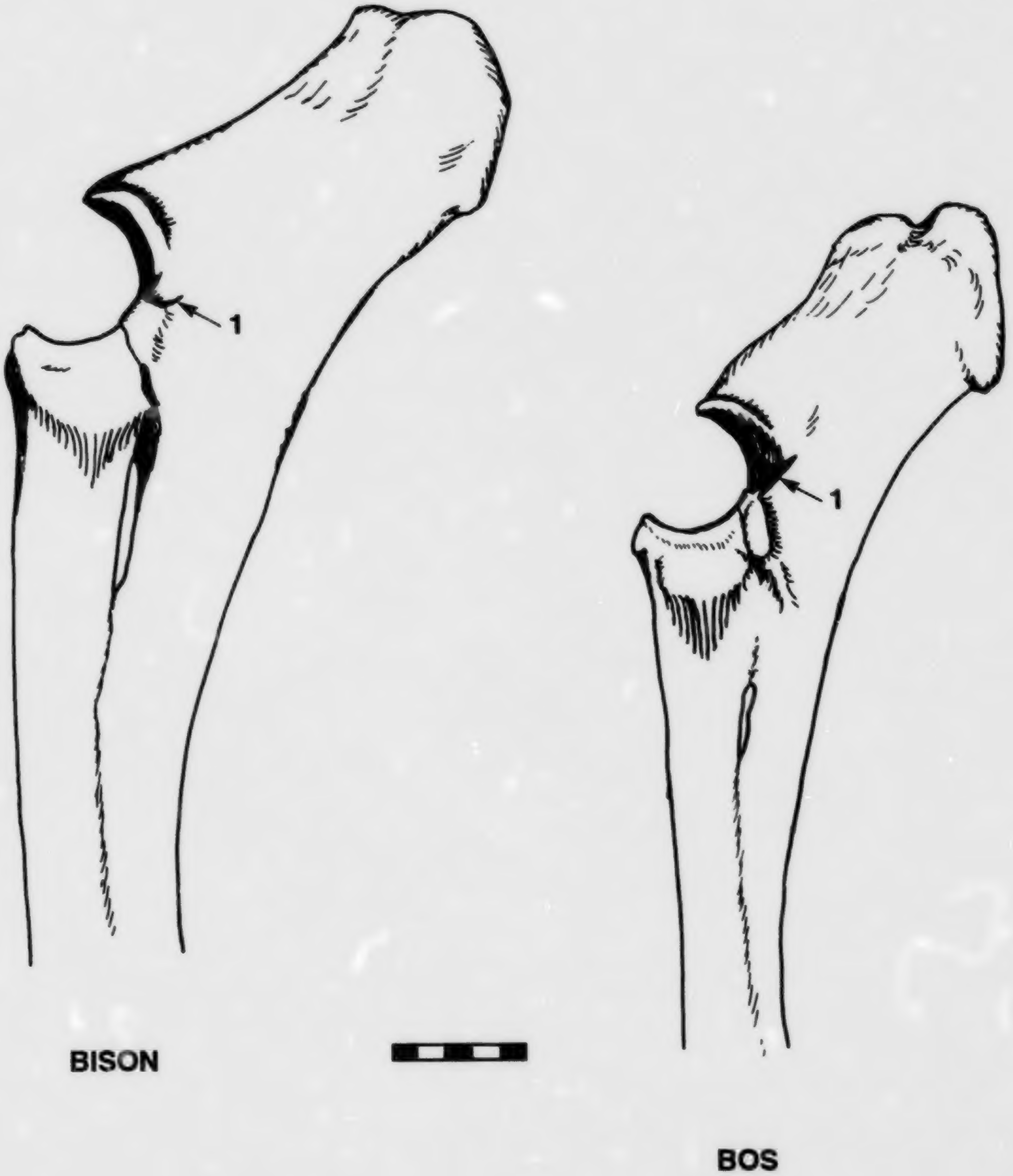
RADIUS AND ULNA

Fig. 35. Radius and Ulna, Lateral View

(1) In *Bison* ulna the ridge from the lateral process (processus coronoideus lateralis) to the semilunar notch is short. This ridge is longer in *Bos*, extending almost up to the semilunar notch.

success rate for *Bison*	24/27 = 88.89%
success rate for *Bos*	13/15 = 86.87%

Character #1: ridge from lateral process	Aspect 1	Aspect 2	Aspect 3
	short	longer	intermediate
No. of *Bison*	24/27	2/27	1/27
No. of *Bos*	2/15	13/15	0/15
Preference Factor *Bison*	5.56	0.10	2.25
Preference Factor *Bos*	0.18	9.64	0.44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BISON
BOS

Figure 35. Proximal Radius and Ulna, Lateral View

RADIUS AND ULNA

Fig. 36. Radius and Ulna, Medial View.

(2)* The scar for the brachialis muscle on the proximal radius is smaller and less excavated in *Bos* than the large rectangular surface in *Bison*. (We have also noticed that the scar tends to wrap around onto the posterior surface in *Bison*).

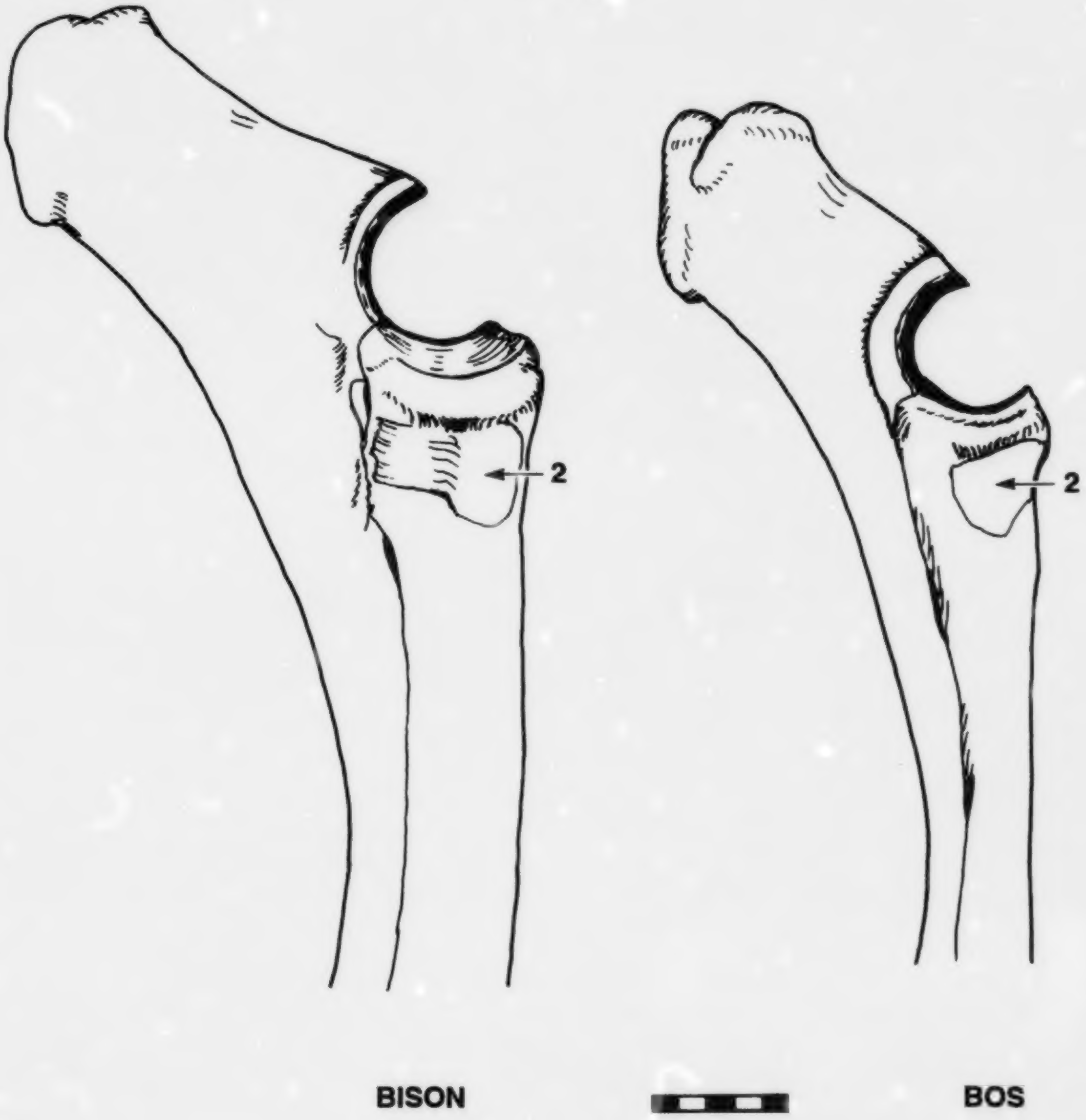
success rate for *Bison*	26/27 = 96.30%
success rate for *Bos*	10/15 = 66.67%

Character #2: scar for brachialis muscle	Aspect 1	Aspect 2	Aspect 3
	large	smaller	intermediate
No. of *Bison*	26/27	1/27	0/27
No. of *Bos*	1/15	10/15	4/15
Preference Factor *Bison*	10.15	0.08	0.05
Preference Factor *Bos*	0.10	12.66	21.66

(3)* In cross-section the ulna shaft forms nearly a right angle with the radius in *Bison*. In *Bos* the contact surface is a gently curved plane with no break or angle. (Not illustrated)

success rate for *Bison*	20/27 = 74.07%
success rate for *Bos*	15/15 = 100.0%

Character #3: junction of shafts of radius and ulna	Aspect 1	Aspect 2	Aspect 3
	right angle	gentle curve	intermediate
No. of *Bison*	20/27	4/27	3/27
No. of *Bos*	0/15	15/15	0/15
Preference Factor *Bison*	31.40	0.16	5.34
Preference Factor *Bos*	0.03	6.12	0.19



BISON

BOS

Figure 36. Proximal Radius and Ulna, Medial View

RADIUS AND ULNA

Fig. 37. Radius, Anterior View

(4)* In *Bison* the lateral tuberosity is less pronounced and more cupped than the knoblike projection in *Bos*.

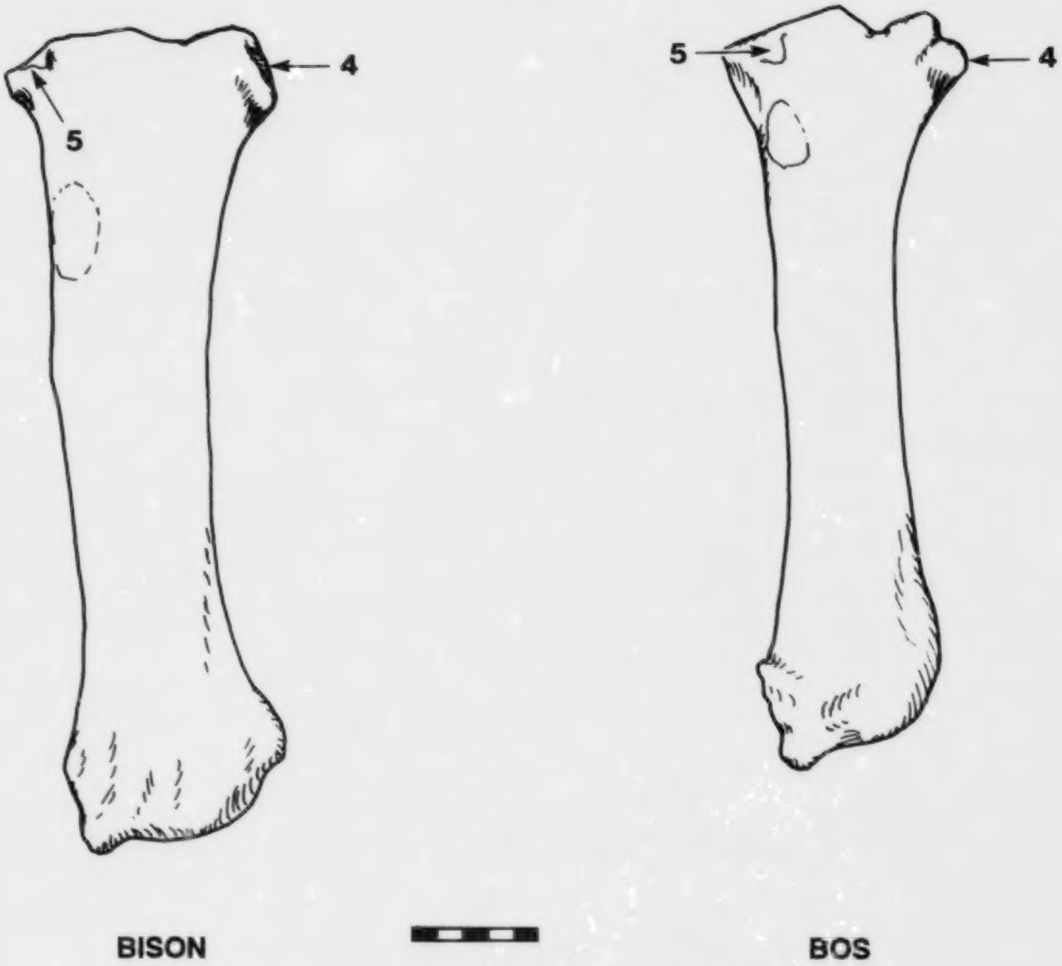
success rate for *Bison*	26/28 = 92.86%
success rate for *Bos*	15/15 = 100.0%

Character #4: lateral tuberosity	Aspect 1	Aspect 2	Aspect 3
	cupped	knoblike	intermediate
No. of *Bison*	26/28	0/28	2/28
No. of *Bos*	0/15	15/15	0/15
Preference Factor *Bison*	39.17	0.01	3.67
Preference Factor *Bos*	0.03	77.47	0.27

(5) The radial tuberosity in *Bison* is small and almost horizontal. In *Bos* it is a pronounced bump which extends further down the shaft.

success rate for *Bison*	22/28 = 78.57%
success rate for *Bos*	8/15 = 53.33%

Character #5: radial tuberosity	Aspect 1	Aspect 2	Aspect 3
	small	pronounced	intermediate
No. of *Bison*	22/28	3/28	3/28
No. of *Bos*	3/15	8/15	4/15
Preference Factor *Bison*	3.51	0.22	0.42
Preference Factor *Bos*	0.29	4.48	2.37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BISON
BOS

Figure 37. Radius, Anterior View

RADIUS AND ULNA

Fig. 37. Radius, Anterior View

(6) The muscle scar below the radial tuberosity is slightly excavated in *Bison*, slightly raised in *Bos*.

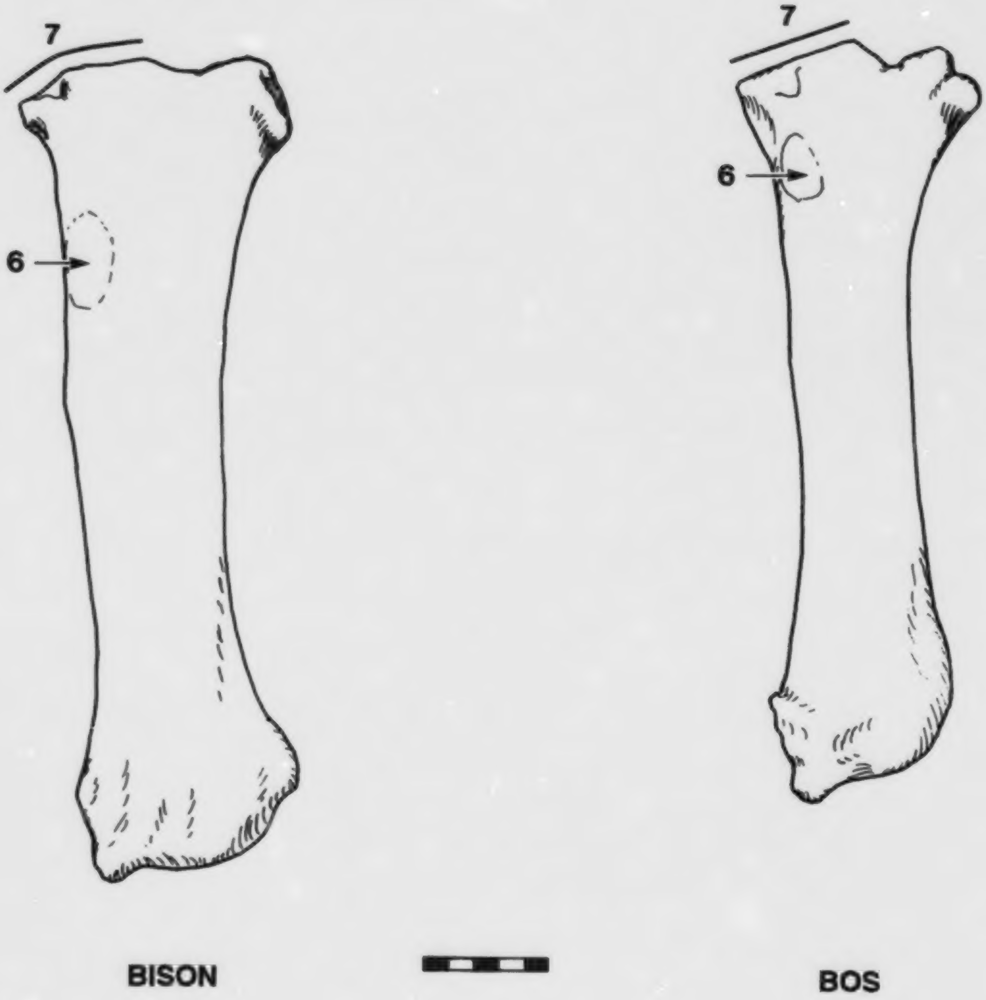
success rate for *Bison*	11/27 = 40.74%
success rate for *Bos*	8/12 = 66.67%

Character #6: muscle scar below radial tuberosity	Aspect 1	Aspect 2	Aspect 3
	excavated	raised	intermediate
No. of *Bison*	11/27	13/27	3/27
No. of *Bos*	4/12	8/12	0/12
Preference Factor *Bison*	1.16	0.72	4.31
Preference Factor *Bos*	0.86	1.38	0.23

(7) The angle of rise from the medial edge of the proximal articular surface to the midpoint of the anterior margin of this surface is steeper in *Bos* than in *Bison*.

success rate for *Bison*	22/28 = 78.57%
success rate for *Bos*	15/15 = 100.0%

Character #7: angle of rise of proximal margin	Aspect 1	Aspect 2	Aspect 3
	gradual	steeper	intermediate
No. of *Bison*	22/28	3/28	3/28
No. of *Bos*	0/15	15/15	0/15
Preference Factor *Bison*	33.26	0.12	5.16
Preference Factor *Bos*	0.03	8.17	0.19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6
7
6
BISON
BOS

Figure 37. Radius, Anterior View

Fig. 37. Radius, Anterior View

(8) The wide central notch in the anterior margin of the proximal articular surface is shallow in *Bison*, deeper and steeper in *Bos*.

success rate for *Bison*	25/28 = 89.29%
success rate for *Bos*	14/15 = 93.33%

Character #8: anterior margin notch	Aspect 1	Aspect 2	Aspect 3
	shallow	deep	intermediate
No. of *Bison*	25/28	3/28	0/28
No. of *Bos*	1/15	14/15	0/15
Preference Factor *Bison*	9.42	0.13	0.54
Preference Factor *Bos*	0.11	7.64	1.84

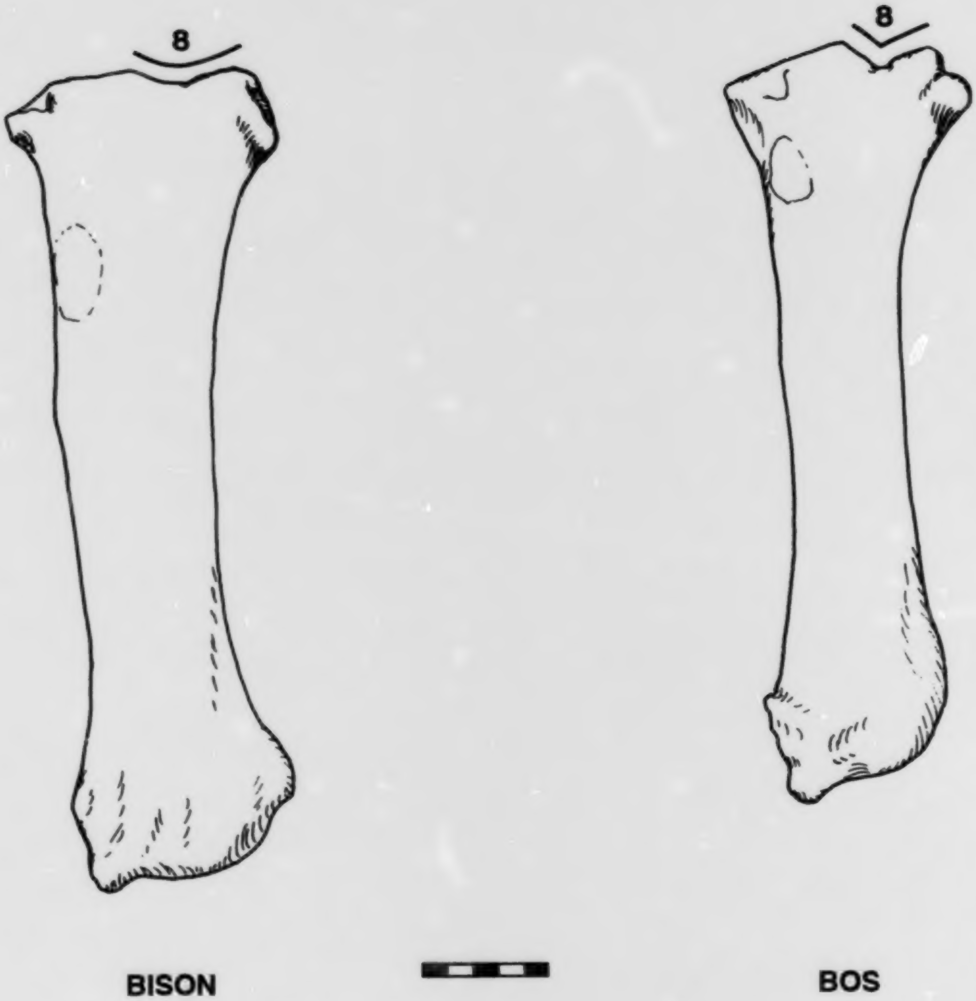

8
8
BISON
BOS

Figure 37. Radius, Anterior View

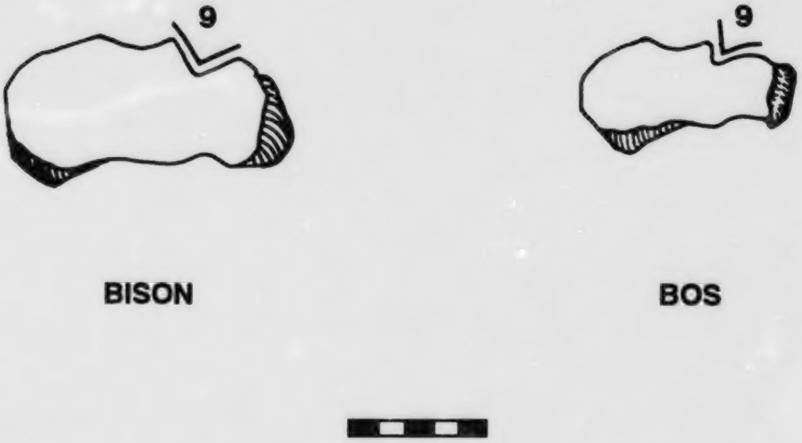
RADIUS AND ULNA

Fig. 38. Radius, Proximal Articular Surface

(9) On the posterior surface of the proximal radius, the notch for articulation with the ulna is sharply stepped, forming almost a right angle in *Bos*, a more obtuse angle in *Bison*.

success rate for *Bison*	12/27 = 44.44%
success rate for *Bos*	15/15 = 100.0%

Character #9: notch for ulna	Aspect 1	Aspect 2	Aspect 3
	obtuse angle	right angle	intermediate
No. of *Bison*	12/27	10/27	5/27
No. of *Bos*	0/15	15/15	0/15
Preference Factor *Bison*	19.14	0.38	8.41
Preference Factor *Bos*	0.05	2.62	0.12



BISON

BOS

Figure 38. Radius, Proximal Articular Surface

RADIUS AND ULNA

Fig. 39. Radius and Ulna, Distal Articular Surface

(10)* In *Bos* the margins defining the facet for the radial carpal converge in a posteromedial direction. These margins remain nearly parallel in *Bison*.

success rate for *Bison*	23/27 = 85.19%
success rate for *Bos*	12/14 = 85.71%

Character #10: margins of carpal facet	Aspect 1	Aspect 2	Aspect 3
	parallel	converge	intermediate
No. of *Bison*	23/27	1/27	3/27
No. of *Bos*	2/14	12/14	0/14
Preference Factor *Bison*	4.99	0.06	5.00
Preference Factor *Bos*	0.20	16.11	0.20

(11) The anterior margin of the facet for the radial carpal is indented in *Bison*, straighter in *Bos*.

success rate for *Bison*	24/27 = 88.89%
success rate for *Bos*	12/14 = 85.71%

Character #11: anterior margin of radial carpal facet	Aspect 1	Aspect 2	Aspect 3
	indented	straighter	intermediate
No. of *Bison*	24/27	3/27	0/27
No. of *Bos*	2/14	12/14	0/14
Preference Factor *Bison*	5.20	0.15	0.53
Preference Factor *Bos*	0.19	6.80	1.90

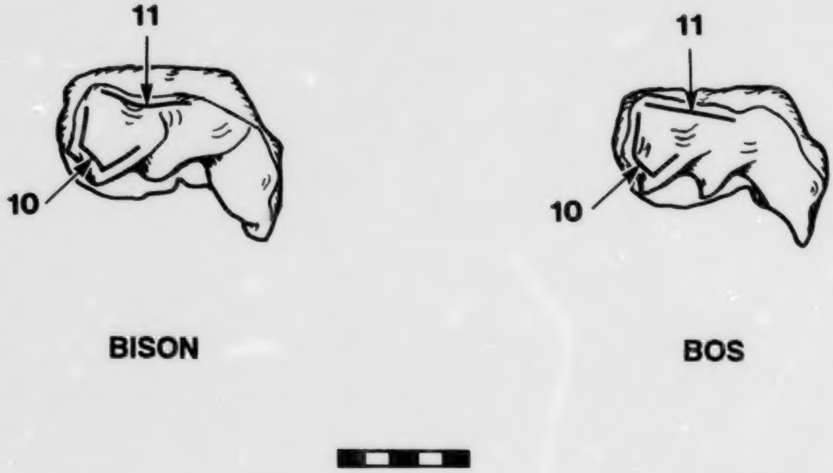

11
10
BISON
11
10
BOS

Figure 39. Radius and Ulna, Distal Articular Surface

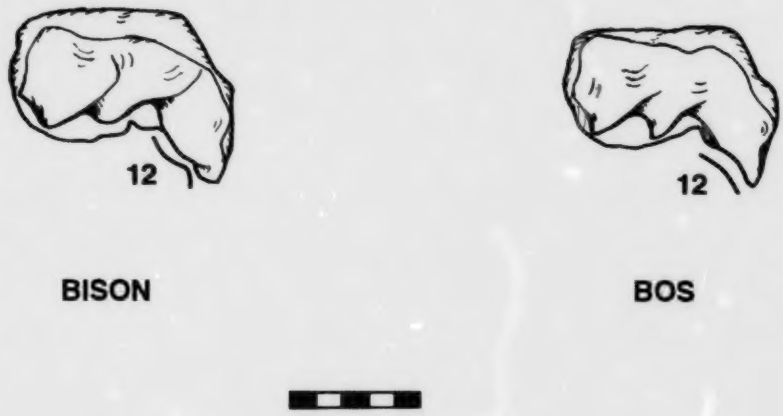
RADIUS AND ULNA

Fig. 39. Radius and Ulna, Distal Articular Surface

(12) The medial margin of the styloid process of the ulna is slightly and smoothly curved in *Bos*. This margin is more strongly curved in *Bison* with a distinct break to form a slight medial hook.

success rate for *Bison*	24/27 = 88.89%
success rate for *Bos*	11/14 = 78.57%

Character #12: medial margin of styloid process	Aspect 1	Aspect 2	Aspect 3
	slight hook	no hook	intermediate
No. of *Bison*	24/27	2/27	1/27
No. of *Bos*	2/14	11/14	1/14
Preference Factor *Bison*	5.20	0.11	0.53
Preference Factor *Bos*	0.19	8.78	1.90



BISON

BOS

Figure 39. Radius and Ulna, Distal Articular Surface

RADIAL CARPAL

Fig. 40. Posterior View

(1) The lateral margin rises to a sharp dorsal peak in *Bison*, a broadly rounded dorsal apex in *Bos*.

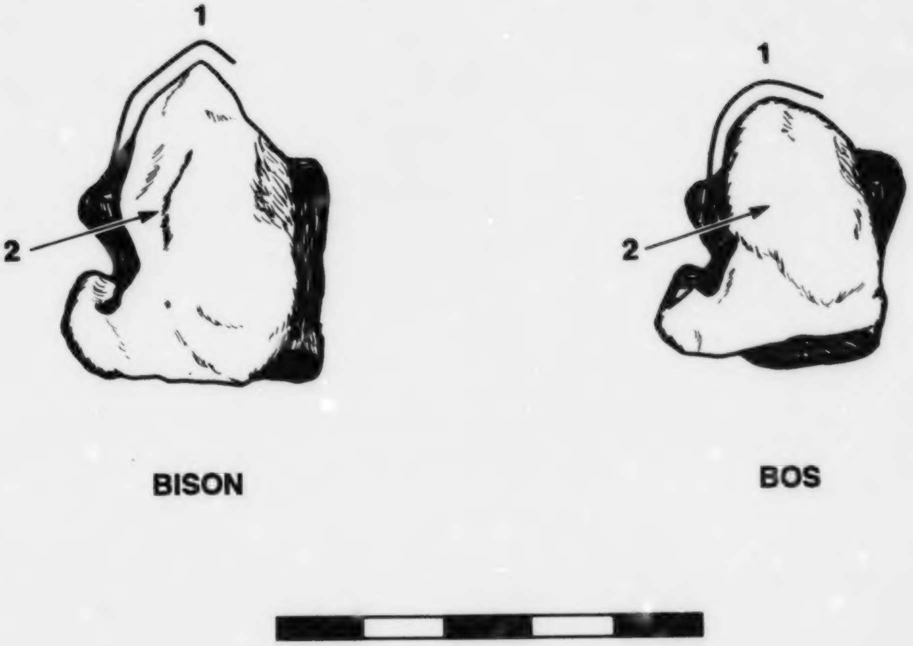
success rate for *Bison*	21/23 = 91.30%
success rate for *Bos*	5/12 = 41.67%

Character #1: lateral margin	Aspect 1	Aspect 2	Aspect 3
	sharp peak	rounded apex	intermediate
No. of *Bison*	21/23	1/23	1/23
No. of *Bos*	7/12	5/12	0/12
Preference Factor *Bison*	1.53	0.14	2.13
Preference Factor *Bos*	0.66	7.02	0.47

(2) The ascending portion of the posterior face is marked by a shallow groove in *Bison*. This groove is lacking in *Bos*.

success rate for *Bison*	18/22 = 81.82%
success rate for *Bos*	8/11 = 72.73%

Character #2: groove in posterior face	Aspect 1	Aspect 2	Aspect 3
	present	absent	intermediate
No. of *Bison*	18/22	1/22	3/22
No. of *Bos*	3/11	8/11	0/11
Preference Factor *Bison*	2.71	0.09	4.84
Preference Factor *Bos*	0.37	11.30	0.21



BISON

BOS

Figure 40. Radial Carpal, Posterior View

RADIAL CARPAL

Fig. 41. Medial View

(3) The posterior margin forms a continuous curve in *Bison*, whereas in *Bos* there is a sharp break in the ventral portion of this margin.

success rate for *Bison*	21/23 = 91.30%
success rate for *Bos*	8/12 = 66.67%

Character #3: curve of posterior margin	Aspect 1	Aspect 2	Aspect 3
	continuous	sharp break	intermediate
No. of *Bison*	21/23	0/23	2/23
No. of *Bos*	3/12	8/12	1/12
Preference Factor *Bison*	3.28	0.02	0.90
Preference Factor *Bos*	0.31	43.42	1.11

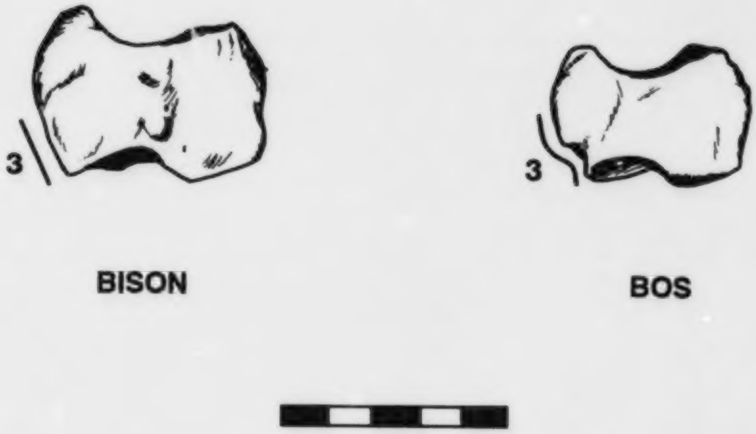

3
3
BISON
BOS

Figure 41. Radial Carpal, Medial View

RADIAL CARPAL

Fig. 42. Lateral View

(4) In *Bison* the antero-ventral articular facet (for the intermediate carpal) extends to the anterior margin of the radial carpal. In *Bos* the dorsal margin of this same facet is angled away from the anterior margin.

success rate for *Bison*	18/21 = 85.71%
success rate for *Bos*	8/12 = 66.67%

Character #4: facet extends to margin	Aspect 1	Aspect 2	Aspect 3
	yes	angled away	intermediate
No. of *Bison*	18/21	2/21	1/21
No. of *Bos*	3/12	8/12	1/12
Preference Factor *Bison*	3.08	0.17	0.58
Preference Factor *Bos*	0.32	5.89	1.72

(5) The ventral and dorsal margins form a distinct "waist" and "hips" in *Bos*, with the anterior portions of these margins converging. In *Bison* this hourglass shape is less well-defined and the anterior portions of the ventral and dorsal margins converge less sharply.

success rate for *Bison*	20/21 = 95.24%
success rate for *Bos*	9/11 = 81.82%

Character #5: "waist" and "hips"	Aspect 1	Aspect 2	Aspect 3
	less distinct	distinct	intermediate
No. of *Bison*	20/21	0/21	1/21
No. of *Bos*	2/11	9/11	0/11
Preference Factor *Bison*	4.41	0.02	2.14
Preference Factor *Bos*	0.23	48.27	0.47

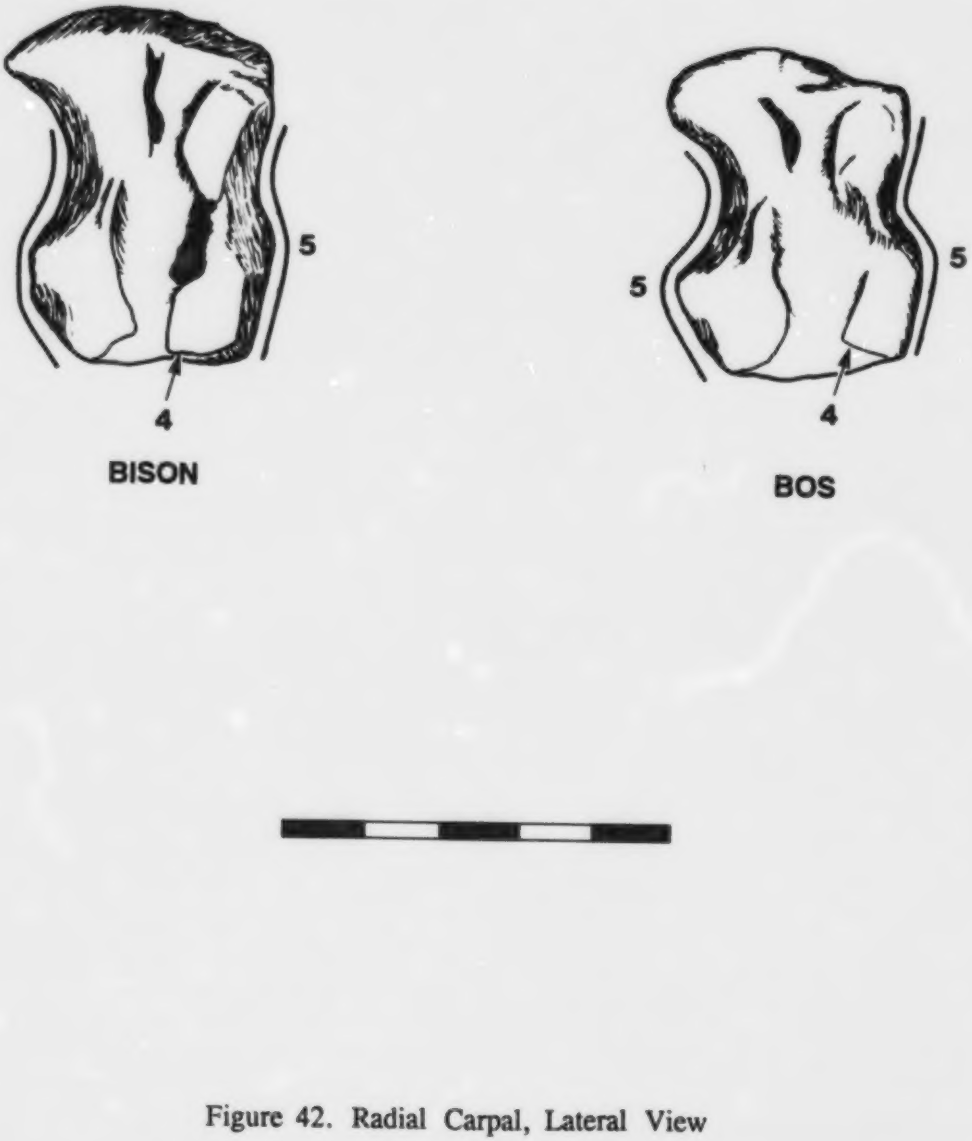

5
4
BISON
5
5
4
BOS

Figure 42. Radial Carpal, Lateral View

RADIAL CARPAL

Fig. 42. Lateral View

(6) The posterior width is relatively greater in *Bison* than in *Bos*, so that rulers held along the dorsal and ventral margins converge anteriorly in *Bison* but are approximately parallel in *Bos*.

success rate for *Bison*	12/20 = 60.00%
success rate for *Bos*	8/11 = 72.73%

Character #6: rulers held along margins	Aspect 1	Aspect 2	Aspect 3
	converge	almost parallel	intermediate
No. of *Bison*	12/20	6/20	2/20
No. of *Bos*	3/11	8/11	0/11
Preference Factor *Bison*	2.01	0.43	3.79
Preference Factor *Bos*	0.50	2.33	0.26

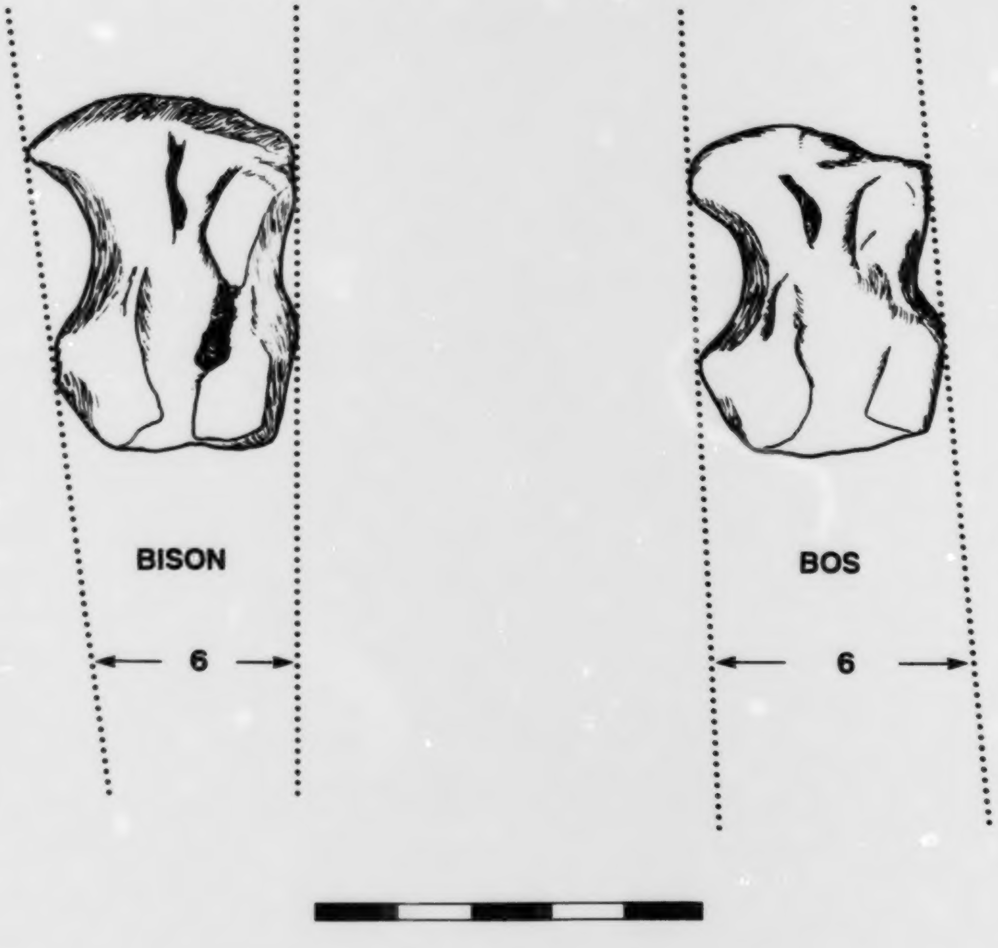

BISON
6
BOS
6

Figure 42. Radial Carpal, Lateral View

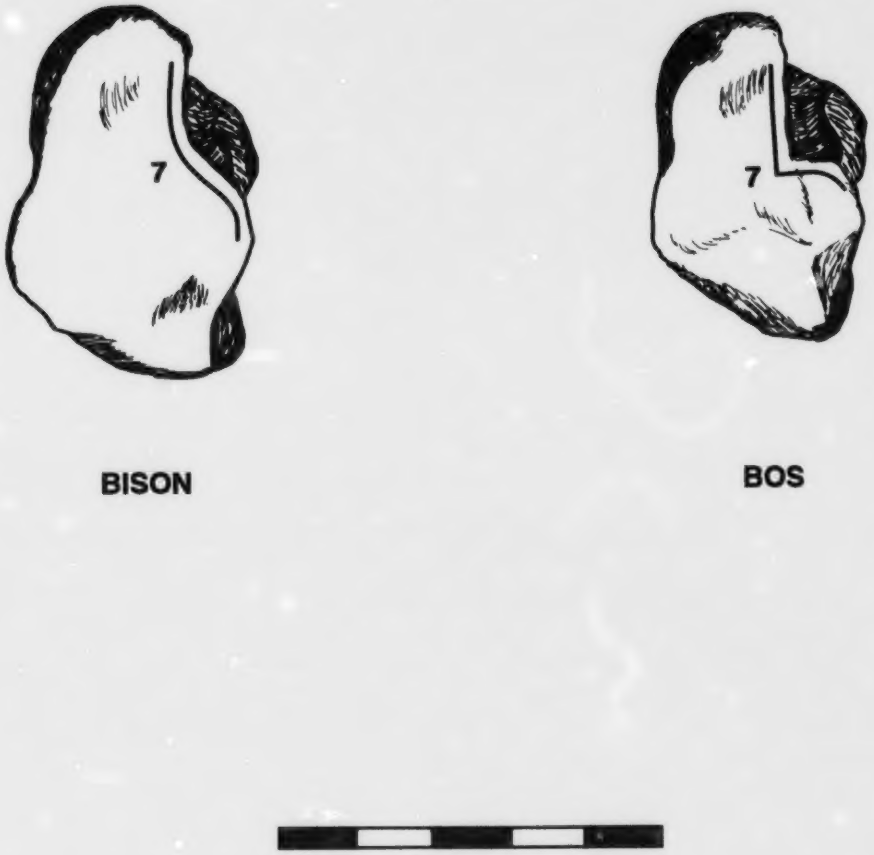
RADIAL CARPAL

Fig. 43. Dorsal View

(7) The lateral extension of the articular surface for the radius approximates a right angle in *Bos*. In *Bison* it forms part of a continuous gentle curve from the dorsal apex.

success rate for *Bison*	15/20 = 75.00%
success rate for *Bos*	8/11 = 72.73%

Character #7: lateral extension of articular surface	Aspect 1	Aspect 2	Aspect 3
	gentle curve	right angle	intermediate
No. of *Bison*	15/20	2/20	3/20
No. of *Bos*	2/11	8/11	1/11
Preference Factor *Bison*	3.50	0.16	1.33
Preference Factor *Bos*	0.29	6.10	0.75



BISON

BOS

Figure 43. Radial Carpal, Dorsal View

INTERMEDIATE CARPAL

Fig. 44. Ventral View

(1) The lateral margin of the ventral articular surface is sharply indented in *Bos*, gently curved in *Bison*.

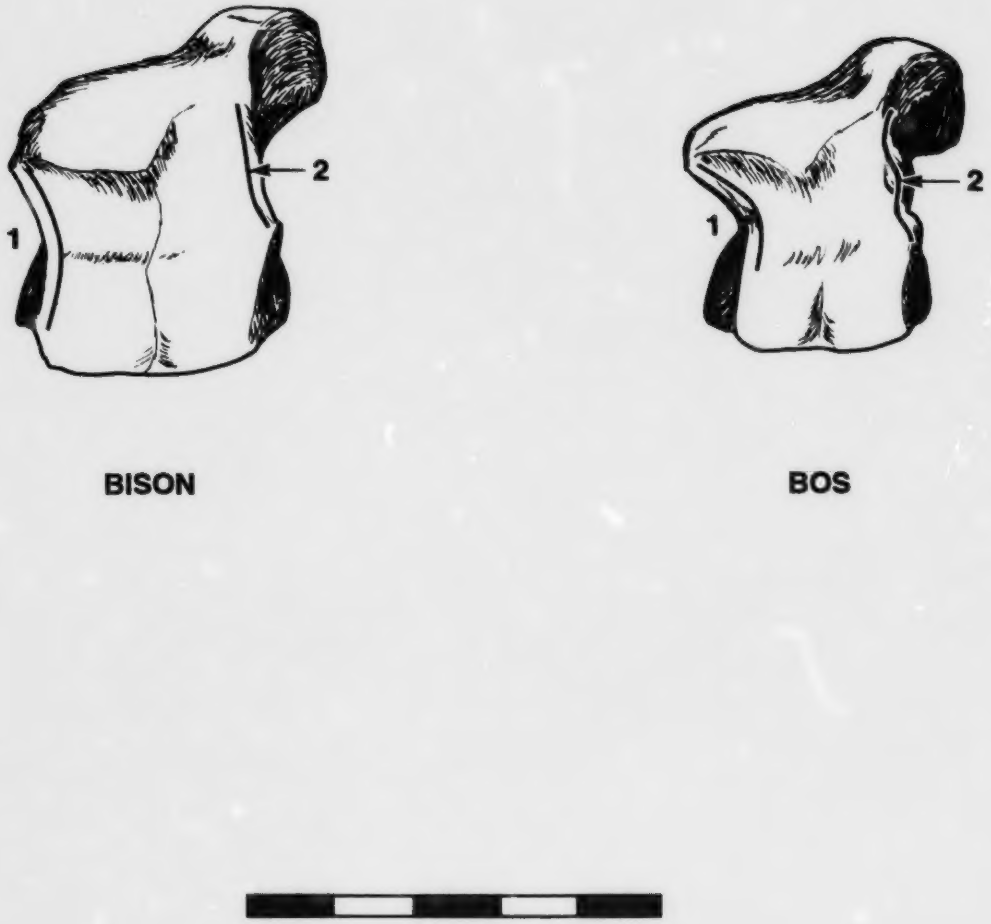
success rate for *Bison*	16/20 = 80.00%
success rate for *Bos*	12/12 = 100.0%

Character #1: lateral margin of articular surface	Aspect 1	Aspect 2	Aspect 3
	gently curved	sharply indented	intermediate
No. of *Bison*	16/20	3/20	1/20
No. of *Bos*	0/12	12/12	0/12
Preference Factor *Bison*	27.34	0.17	2.44
Preference Factor *Bos*	0.04	5.88	0.41

(2) The posteromedial margin of the ventral articular surface is straight or slightly concave in *Bison*, a serpentine curve in *Bos*.

success rate for *Bison*	8/20 = 40.00%
success rate for *Bos*	12/12 = 100.0%

Character #2: posteromedial margin	Aspect 1	Aspect 2	Aspect 3
	straight or concave	serpentine curve	intermediate
No. of *Bison*	8/20	10/20	2/20
No. of *Bos*	0/12	12/12	0/12
Preference Factor *Bison*	14.08	0.51	4.12
Preference Factor *Bos*	0.07	1.95	0.24



BISON

BOS

Figure 44. Intermediate Carpal, Ventral View

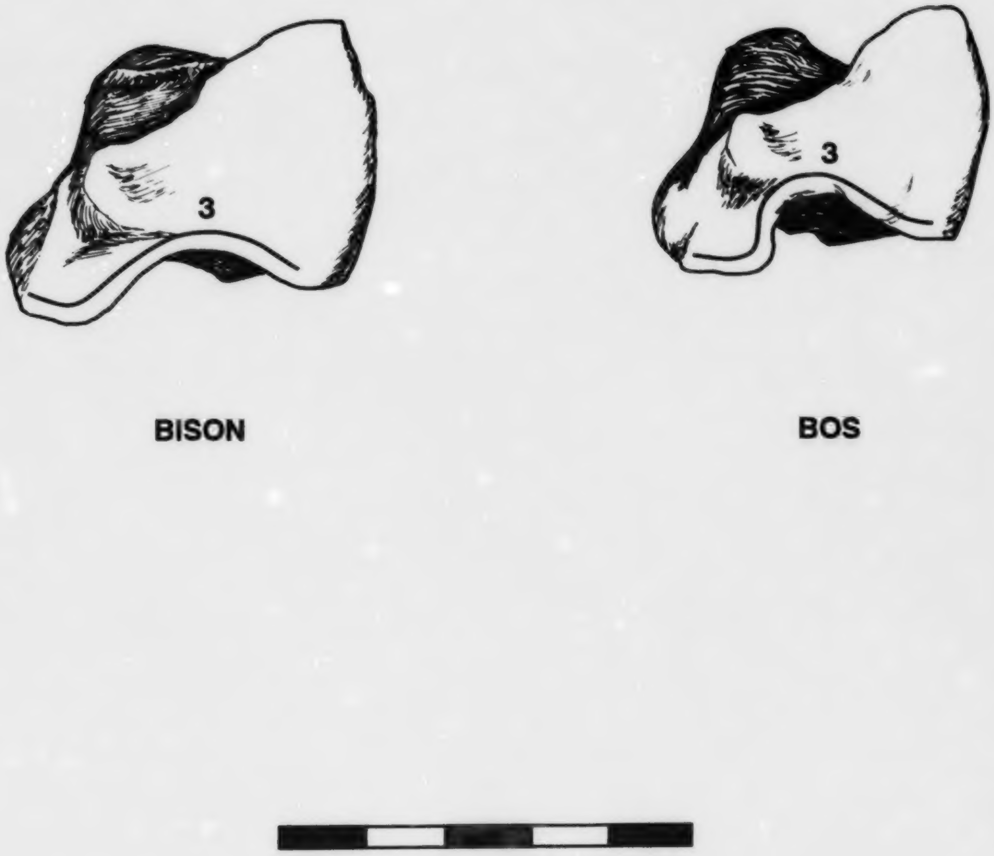
INTERMEDIATE CARPAL

Fig. 45. Dorsal View

(3) The medial margin is a smooth curve in *Bison*. In *Bos* the anterior portion of this margin is flattened, with an abrupt break to form the semilunar notch.

success rate for *Bison*	20/20 = 100.0%
success rate for *Bos*	6/12 = 50.00%

Character #3: medial margin	Aspect 1	Aspect 2	Aspect 3
	smooth curve	abrupt break	intermediate
No. of *Bison*	20/20	0/20	0/20
No. of *Bos*	6/12	6/12	0/12
Preference Factor *Bison*	1.92	0.03	0.61
Preference Factor *Bos*	0.52	28.95	1.64



BISON

BOS

Figure 45. Intermediate Carpal, Dorsal View

INTERMEDIATE CARPAL

Fig. 46. Posterior View

(4) The ventral margin comes to a point laterally in *Bos*, but is more rounded in *Bison*.

success rate for *Bison*	14/14 = 100.0%
success rate for *Bos*	**6/6 = 100.0%

Character #4: ventral margin	Aspect 1	Aspect 2	Aspect 3
	rounded	pointed	intermediate
No. of *Bison*	14/14	0/14	0/14
No. of *Bos*	0/6	6/6	0/6
Preference Factor *Bison*	17.65	0.03	0.45
Preference Factor *Bos*	0.06	39.41	2.23

** Note that *Bos* sample size is very small.

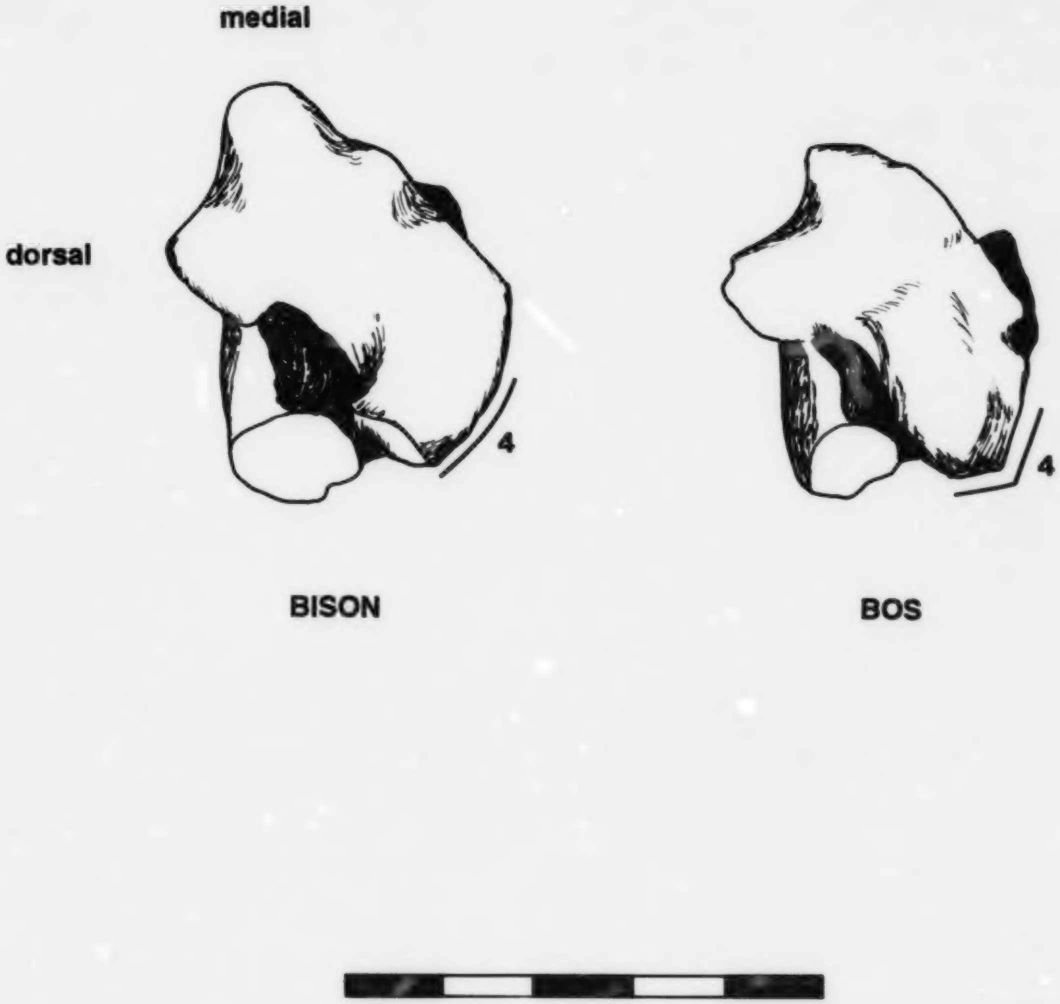

medial
dorsal
4
4
BISON
BOS

Figure 46. Intermediate Carpal, Posterior View

ULNAR CARPAL

Fig. 47. Medial View

(1) The articular facets for the intermediate carpal are separated by a groove or channel in *Bos*, a deep pit in *Bison*.

success rate for *Bison*	11/23 = 47.83%
success rate for *Bos*	8/12 = 66.67%

Character #1: separation of articular facets	Aspect 1	Aspect 2	Aspect 3
	deep pit	channel	intermediate
No. of *Bison*	11/23	12/23	0/23
No. of *Bos*	2/12	8/12	2/12
Preference Factor *Bison*	2.46	0.78	0.08
Preference Factor *Bos*	0.41	1.28	12.69

(2) The articular facet for the accessory carpal is almost straight in *Bison*, sharply indented in *Bos*.

success rate for *Bison*	24/24 = 100.0%
success rate for *Bos*	11/12 = 91.67%

Character #2: articular facet for accessory carpal	Aspect 1	Aspect 2	Aspect 3
	straight	indented	intermediate
No. of *Bison*	24/24	0/24	0/24
No. of *Bos*	1/12	11/12	0/12
Preference Factor *Bison*	8.49	0.02	0.51
Preference Factor *Bos*	0.12	61.26	1.96

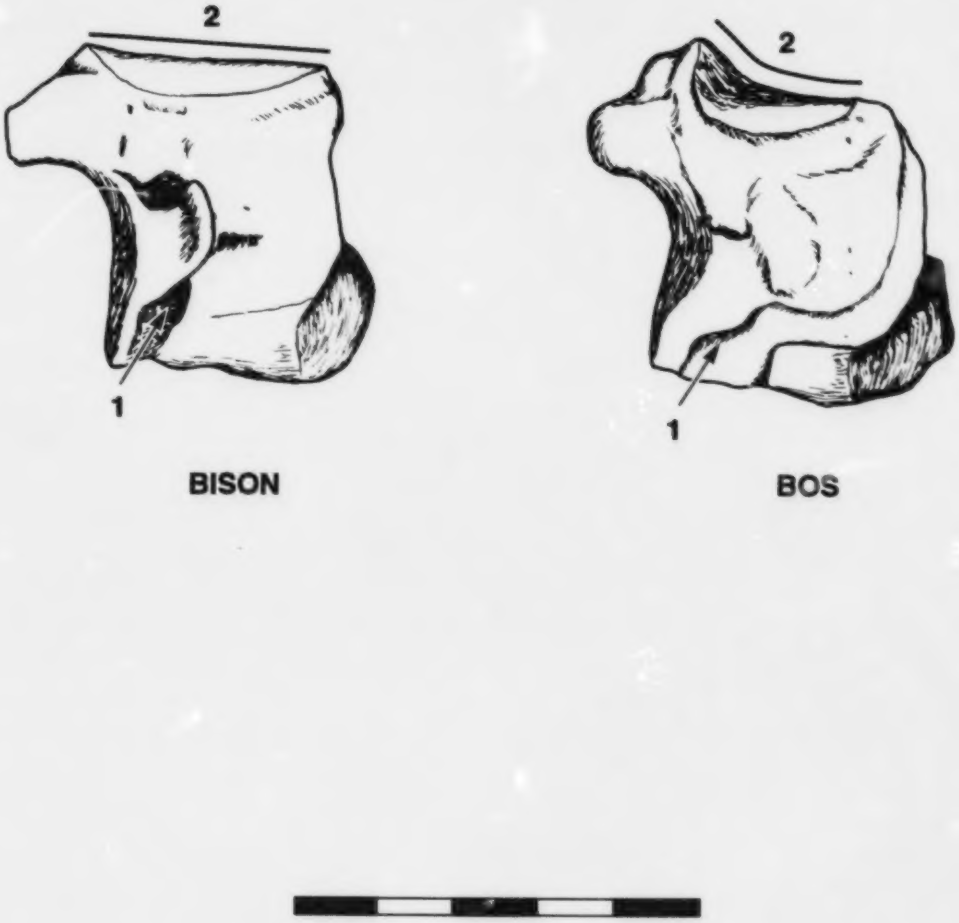

2
1
BISON
2
1
BOS

Figure 47. Ulnar Carpal, Medial View

ULNAR CARPAL

Fig. 47. Medial View

(3) The posterior portion of the proximal margin (near the articular facet for the accessory carpal) is convex in *Bos*, straight or concave in *Bison*.

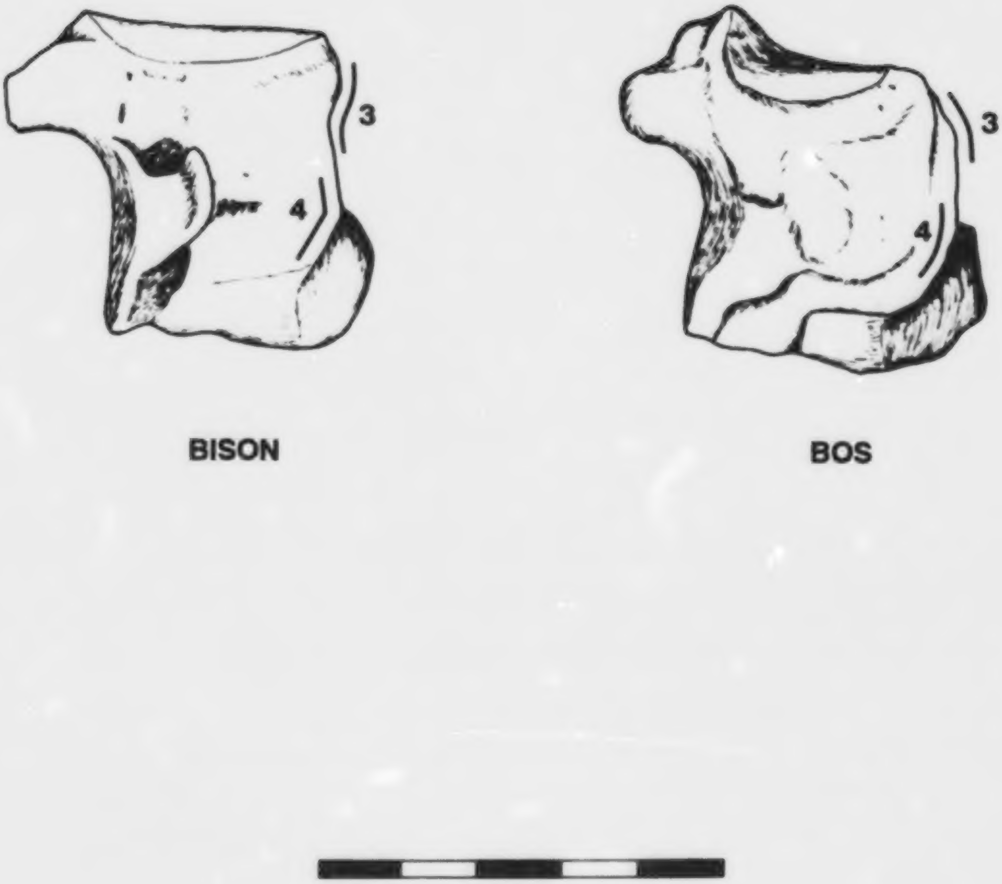
success rate for *Bison*	23/24 = 95.83%
success rate for *Bos*	9/12 = 75.00%

Character #3: posterior portion of proximal margin	Aspect 1	Aspect 2	Aspect 3
	straight	convex	intermediate
No. of *Bison*	23/24	0/24	1/24
No. of *Bos*	2/12	9/12	1/12
Preference Factor *Bison*	4.83	0.02	0.51
Preference Factor *Bos*	0.21	50.60	1.96

(4) The corner formed by the junction of facets for the ulna and the intermediate carpal is rounded in *Bos*, angular in *Bison*.

success rate for *Bison*	22/24 = 91.67%
success rate for *Bos*	8/12 = 66.67%

Character #4: junction of facets	Aspect 1	Aspect 2	Aspect 3
	angular	rounded	intermediate
No. of *Bison*	22/24	2/24	0/24
No. of *Bos*	3/12	8/12	1/12
Preference Factor *Bison*	3.29	0.15	0.13
Preference Factor *Bos*	0.30	6.71	7.84



BISON

BOS

Figure 47. Ulnar Carpal, Medial View

ACCESSORY CARPAL

Fig. 48. Volar View

(1) In *Bison* the articular surface lips over at the union of the ulna, ulnar carpal and accessory carpal.

success rate for *Bison*	19/22 = 86.36%
success rate for *Bos*	8/11 = 72.73%

Character #1: articular surface	Aspect 1	Aspect 2	Aspect 3
	lips over	does not lip over	intermediate
No. of *Bison*	19/22	3/22	0/22
No. of *Bos*	2/11	8/11	1/11
Preference Factor *Bison*	4.01	0.21	0.13
Preference Factor *Bos*	0.25	4.77	7.83

(2) In *Bos* this element gives an overall impression of roundness and knobbiness, whereas in *Bison* it is appears more flattened than round. (Shown but not marked)

success rate for *Bison*	19/22 = 86.36%
success rate for *Bos*	9/11 = 81.82%

Character #2: overall impression	Aspect 1	Aspect 2	Aspect 3
	more flat than round	round and knobby	intermediate
No. of *Bison*	19/22	3/22	0/22
No. of *Bos*	0/11	9/11	2/11
Preference Factor *Bison*	27.08	0.19	0.08
Preference Factor *Bos*	0.04	5.33	13.21

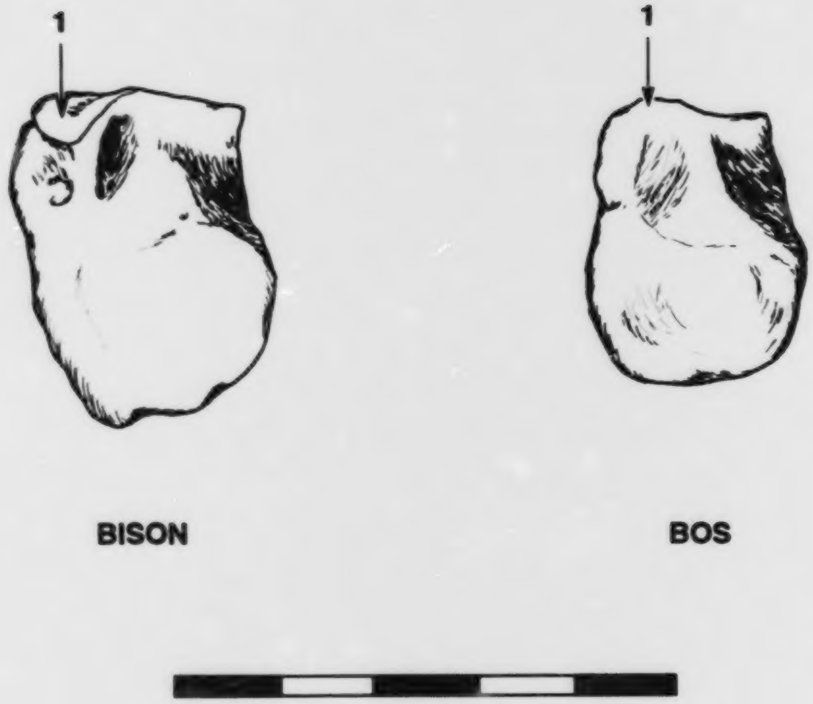

1
1
BISON
BOS

Figure 48. Accessory Carpal, Volar View

CARPAL 2+3

Fig. 49. Posterior View

(1) The articular surface extends to the medial margin in *Bison*, but curves away laterally in *Bos*.

success rate for *Bison*	22/23 = 95.65%
success rate for *Bos*	11/12 = 91.67%

Character #1: articular surface	Aspect 1	Aspect 2	Aspect 3
	extends to medial margin	curves away laterally	intermediate
No. of *Bison*	22/23	1/23	0/23
No. of *Bos*	1/12	11/12	0/12
Preference Factor *Bison*	8.13	0.07	0.53
Preference Factor *Bos*	0.12	14.69	1.88

(2) The articular surface extends almost to the ventral margin in *Bos*, whereas in *Bison* this surface is angled dorsally away from the ventral margin.

success rate for *Bison*	10/23 = 43.48%
success rate for *Bos*	9/12 = 75.00%

Character #2: articular surface	Aspect 1	Aspect 2	Aspect 3
	angled away dorsally	extends to ventral margin	intermediate
No. of *Bison*	10/23	6/23	7/23
No. of *Bos*	3/12	9/12	0/12
Preference Factor *Bison*	1.60	0.36	10.83
Preference Factor *Bos*	0.62	2.75	0.09

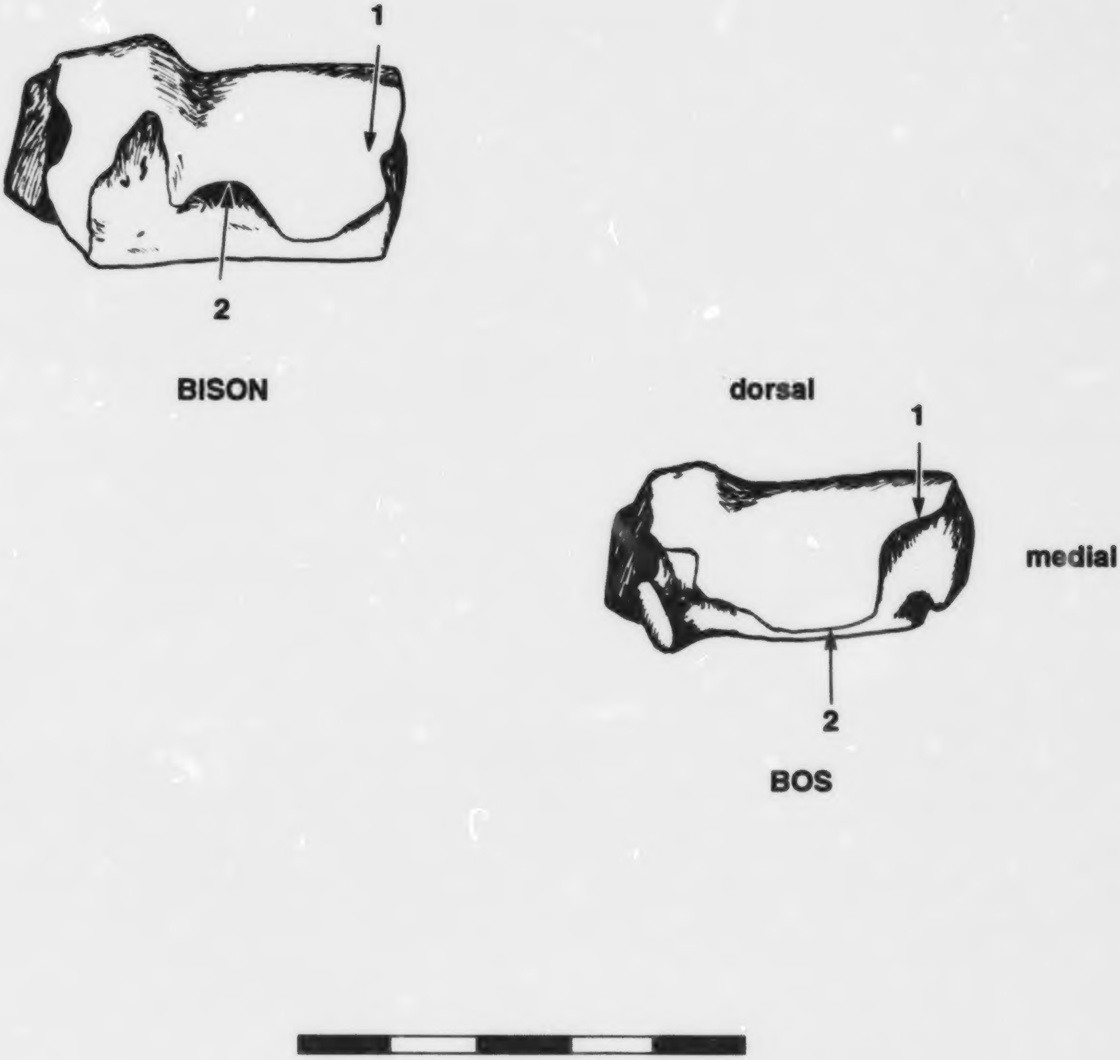

1
2
BISON
dorsal
1
medial
2
BOS

Figure 49. Carpal 2+3, Posterior View

CARPAL 2+3

Fig. 49. Posterior View

(3) *Bison* are thicker dorsoventrally than *Bos*. However, this character should be used with caution, and never on its own, as it may well be size- or sex-dependent.

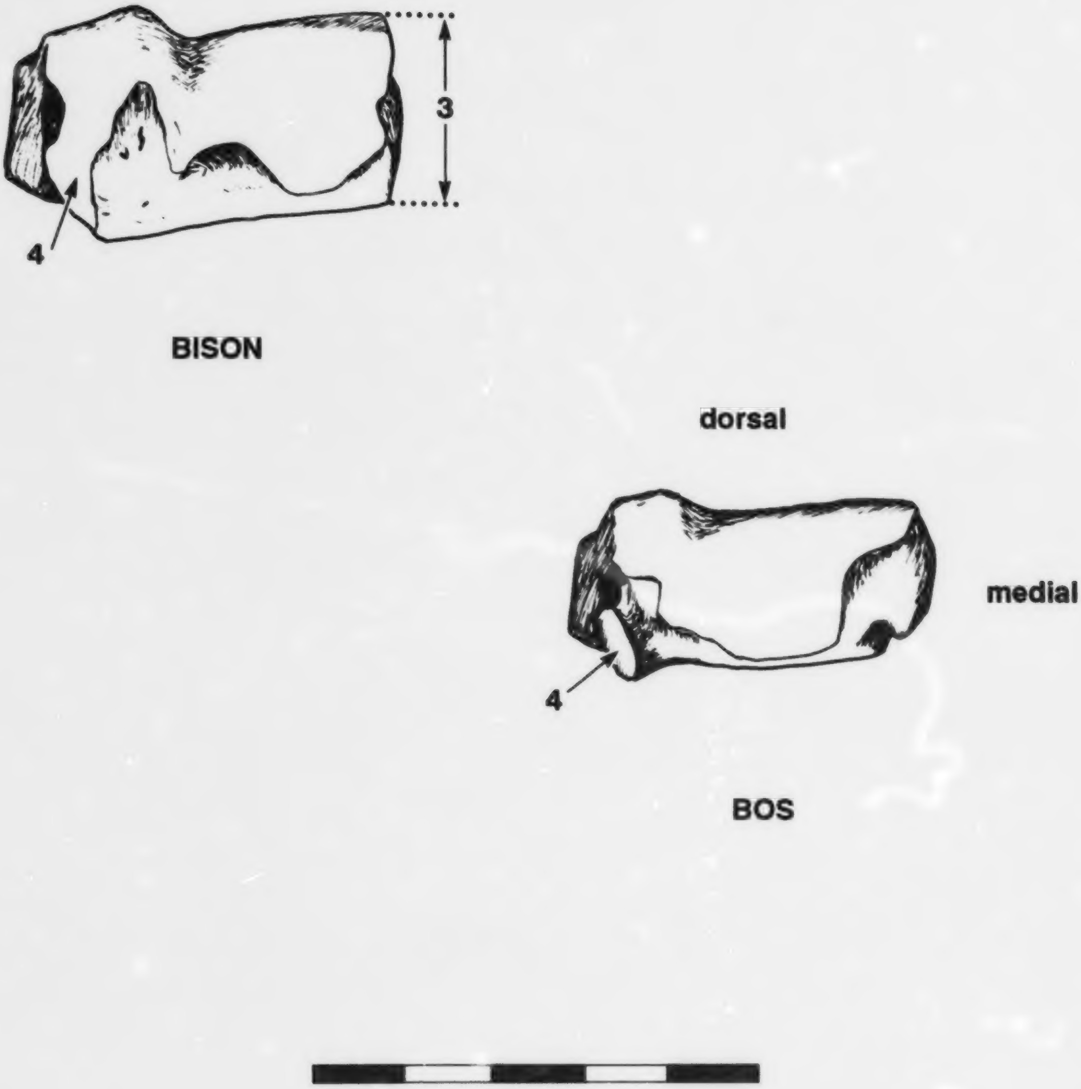
success rate for *Bison*	23/23 = 100.0%
success rate for *Bos*	9/12 = 75.00%

Character #3: dorsoventral thickness	Aspect 1	Aspect 2	Aspect 3
	greater	lesser	intermediate
No. of *Bison*	23/23	0/23	0/23
No. of *Bos*	2/12	9/12	1/12
Preference Factor *Bison*	5.03	0.02	0.13
Preference Factor *Bos*	0.20	48.54	7.52

(4) The posterior articular facet for carpal 4 projects slightly as a separate island in *Bos*. In *Bison*, this facet is continuous with the articular facet for the intermediate carpal.

success rate for *Bison*	16/23 = 69.57%
success rate for *Bos*	9/12 = 75.00%

Character #4: articular facet for carpal 4	Aspect 1	Aspect 2	Aspect 3
	continuous	separate	intermediate
No. of *Bison*	16/23	4/23	3/23
No. of *Bos*	3/12	9/12	0/12
Preference Factor *Bison*	2.52	0.25	5.04
Preference Factor *Bos*	0.40	3.98	0.20


3
4
dorsal
medial
4

BISON

BOS

Figure 49. Carpal 2+3, Posterior View

CARPAL 2+3

Fig. 49. Posterior View

(5) The lateral portion of the dorsal margin rises steeply from the medial portion in *Bison*. In *Bos*, the angle of rise and the degree of projection are less than in *Bison*.

success rate for *Bison*	20/20 = 100.0%
success rate for *Bos*	12/12 = 100.0%

Character #5: lateral portion of dorsal margin	Aspect 1	Aspect 2	Aspect 3
	steep rise	shallow rise	intermediate
No. of *Bison*	20/20	0/20	0/20
No. of *Bos*	0/12	12/12	0/12
Preference Factor *Bison*	33.97	0.02	0.61
Preference Factor *Bos*	0.03	55.72	1.64

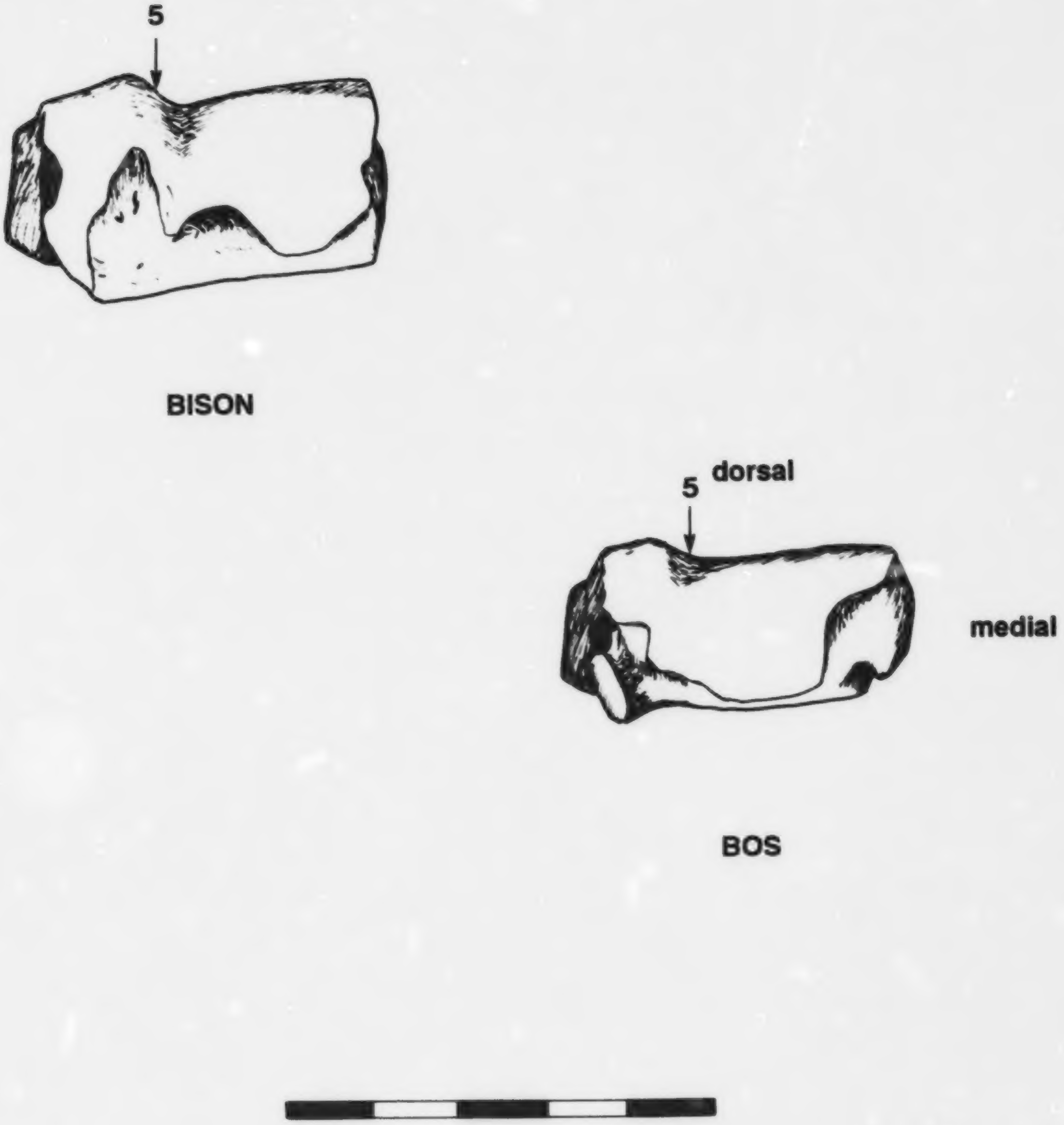

5
BISON
5
dorsal
medial
BOS

Figure 49. Carpal 2+3, Posterior View

CARPAL 4

Fig. 50. Posterior View

(1) The ventral margin is almost straight in *Bison*, but has a sharp dip near the middle in *Bos*.

success rate for *Bison*	23/24 = 95.83%
success rate for *Bos*	9/13 = 69.23%

Character #1: ventral margin	Aspect 1	Aspect 2	Aspect 3
	straight	sharp dip	intermediate
No. of *Bison*	23/24	0/24	1/24
No. of *Bos*	4/13	9/13	0/13
Preference Factor *Bison*	2.88	0.02	2.20
Preference Factor *Bos*	0.35	46.85	0.45

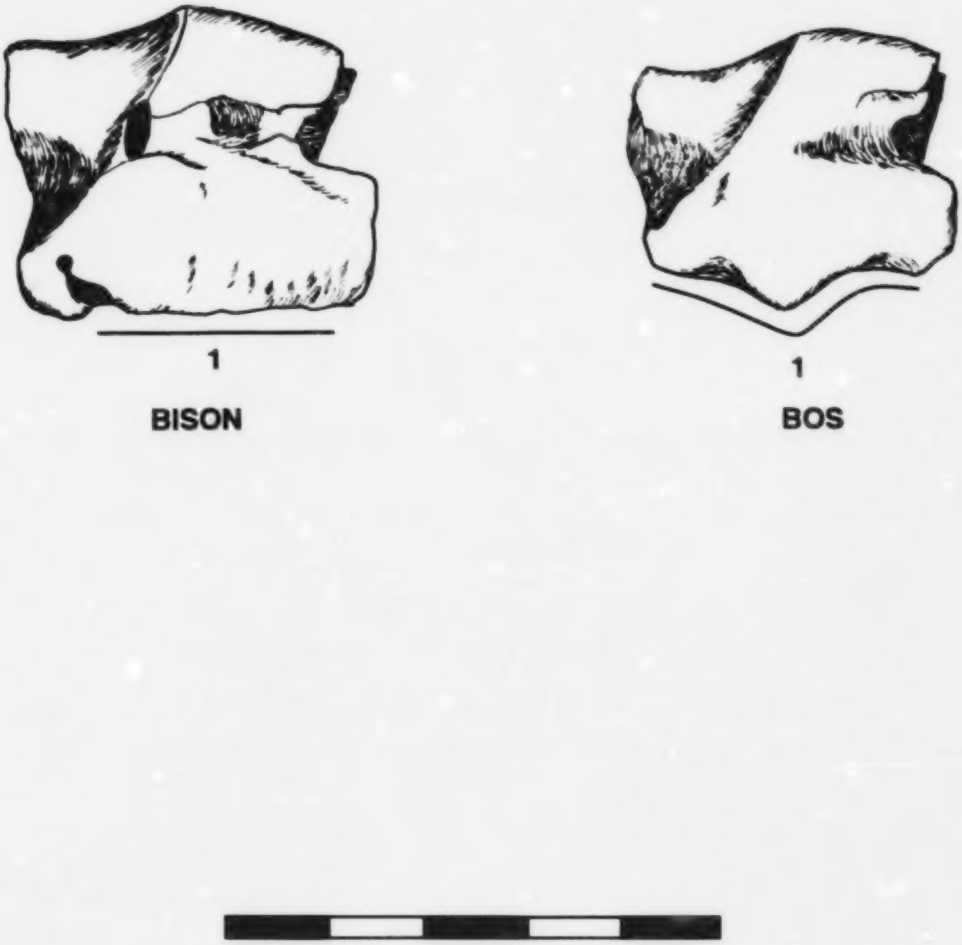

1
BISON
1
BOS

Figure 50. Carpal 4, Posterior View

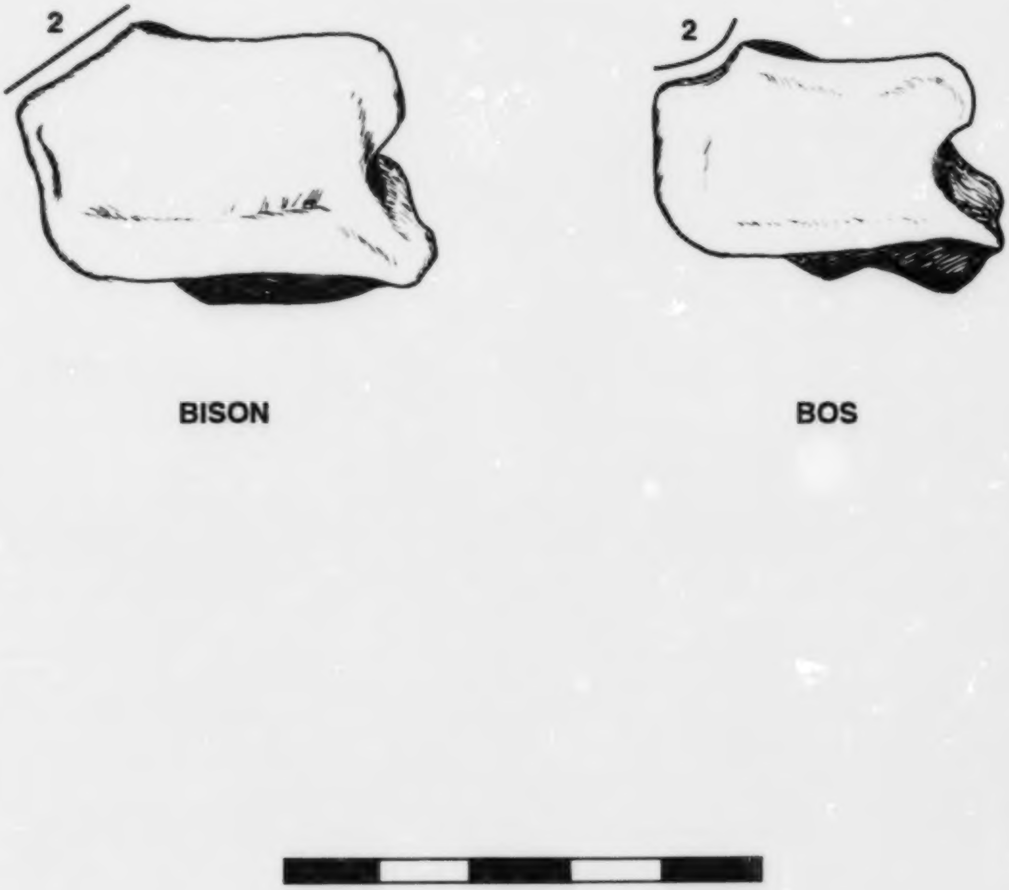
CARPAL 4

Fig. 51. Anterior View

(2) In *Bison* the medial portion of the dorsal margin rises gradually in an almost straight line to a peak approximately a third of the way along. In *Bos*, the rise is more abrupt and curved, reaching a peak about a quarter of the way along the margin.

success rate for *Bison*	6/23 = 26.09%
success rate for *Bos*	12/13 = 92.31%

Character #2: medial portion of dorsal margin	Aspect 1	Aspect 2	Aspect 3
	gradual rise; straight	more abrupt rise; curved	intermediate
No. of *Bison*	6/23	14/23	3/23
No. of *Bos*	1/13	12/13	0/13
Preference Factor *Bison*	2.53	0.67	5.45
Preference Factor *Bos*	0.39	1.50	0.18



BISON

BOS

Figure 51. Carpal 4, Anterior View

METACARPAL 3+4

Fig. 52. Dorsal View

(1) In *Bos* the overall shape is rather long and narrow; it is wider and slightly shorter in *Bison*, giving an impression of bulkiness. (Shown but not marked)

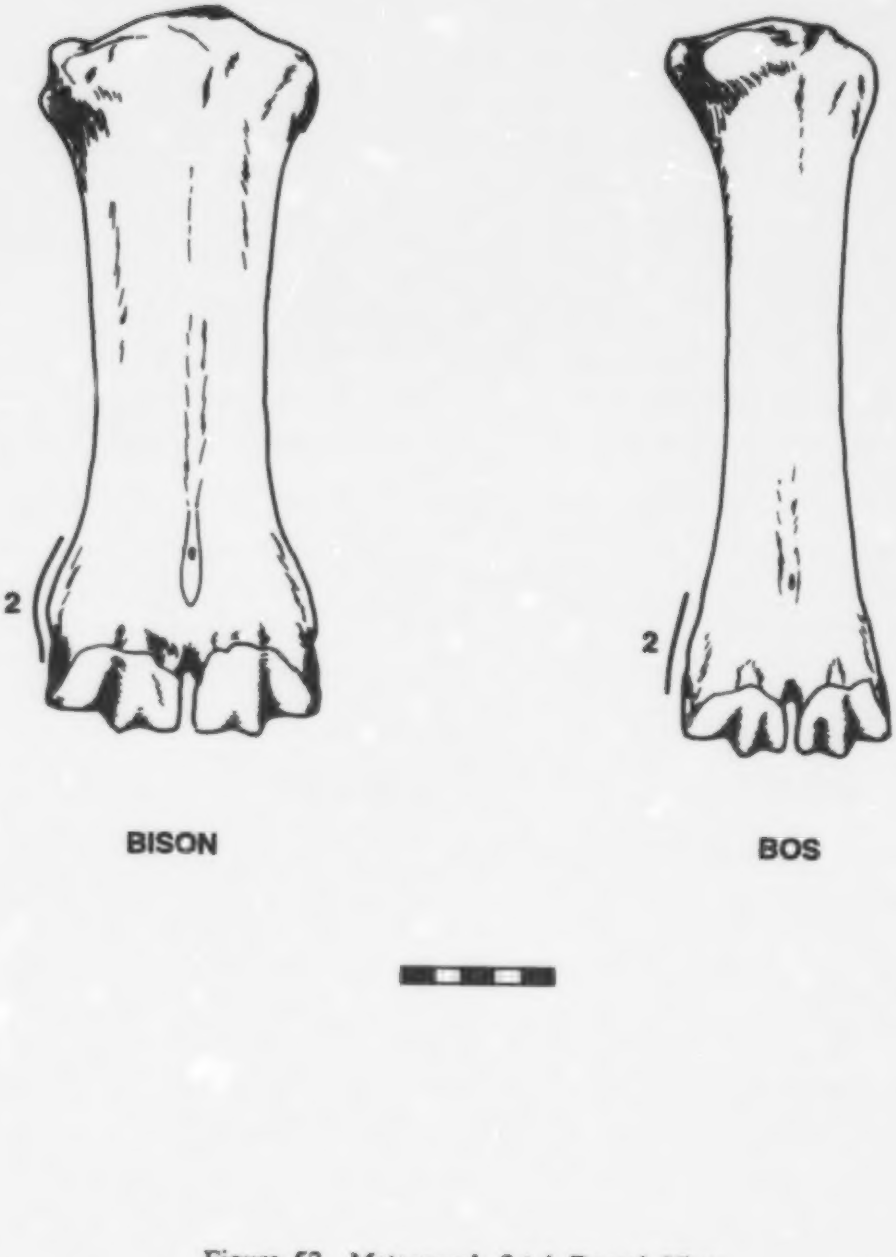
success rate for *Bison*	21/27 = 77.78%
success rate for *Bos*	10/13 = 76.92%

Character #1: overall shape	Aspect 1	Aspect 2	Aspect 3
	wider	narrower	intermediate
No. of *Bison*	21/27	4/27	2/27
No. of *Bos*	3/13	10/13	0/13
Preference Factor *Bison*	3.03	0.21	3.31
Preference Factor *Bos*	0.33	4.76	0.30

(2)* In anterior view, *Bison* show a swelling above the distal condyles; *Bos* do not.

success rate for *Bison*	25/25 = 100.0%
success rate for *Bos*	10/13 = 76.92%

Character #2: swelling above condyles	Aspect 1	Aspect 2	Aspect 3
	present	absent	intermediate
No. of *Bison*	25/25	0/25	0/25
No. of *Bos*	3/13	10/13	0/13
Preference Factor *Bison*	3.87	0.02	0.53
Preference Factor *Bos*	0.26	53.90	1.89



BISON

BOS

Figure 52. Metacarpal 3+4, Dorsal View

METACARPAL 3+4

Fig. 53. Proximal Surface

(3) The greatest proximal width (GPW) for *Bos* occurs roughly along the posterior edge. In *Bison* the GPW is angled anteriorly to the protuberance of the articular surface for carpal 2+3.

success rate for *Bison*	22/26 = 84.62%
success rate for *Bos*	9/12 = 75.00%

Character #3: G.P.W. orientation	Aspect 1	Aspect 2	Aspect 3
	angled anteriorly	along posterior edge	intermediate
No. of *Bison*	22/26	4/26	0/26
No. of *Bos*	3/12	9/12	0/12
Preference Factor *Bison*	3.04	0.22	0.47
Preference Factor *Bos*	0.33	4.48	2.12

(4)* In *Bison* the point of contact between the tubercle and the posterior margin of the articular surface for carpal 2+3 is slight, leaving a noticeable gap between the two surfaces. In *Bos* the tubercle is completely fused to the main bone.

success rate for *Bison*	23/26 = 88.46%
success rate for *Bos*	9/12 = 75.00%

Character #4: amount of contact	Aspect 1	Aspect 2	Aspect 3
	slight	complete	intermediate
No. of *Bison*	23/26	3/26	0/26
No. of *Bos*	2/12	9/12	1/12
Preference Factor *Bison*	4.46	0.17	0.12
Preference Factor *Bos*	0.22	5.77	8.48

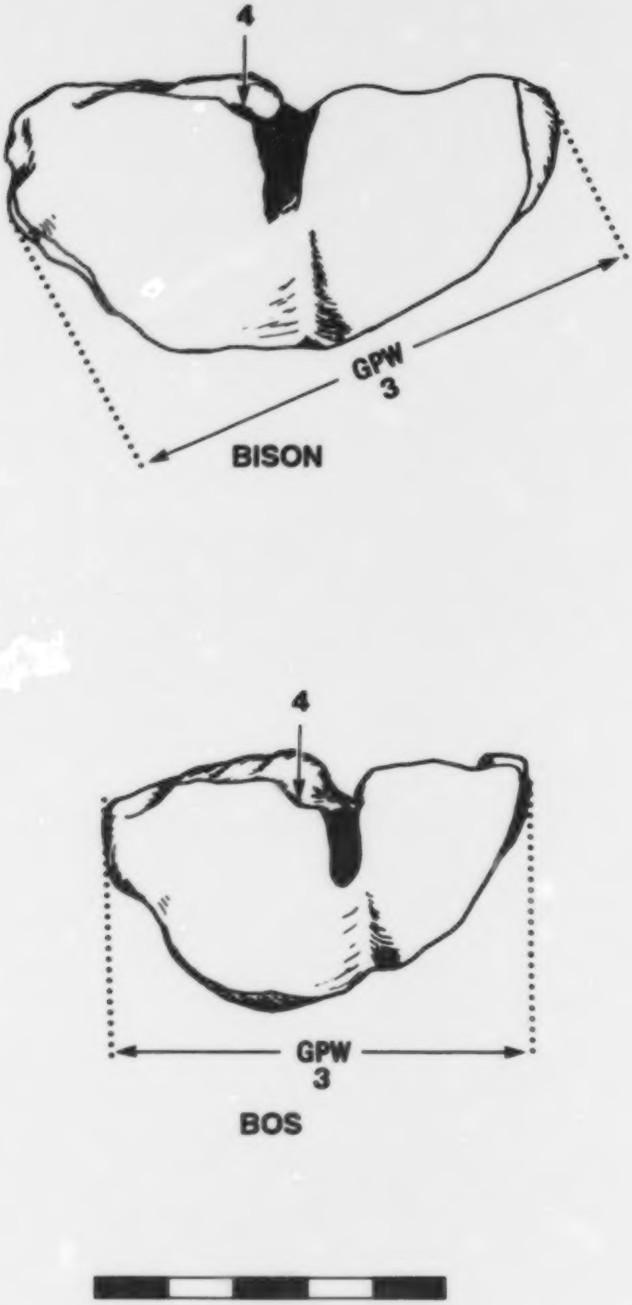

4
GPW
3
BISON
4
GPW
3
BOS

Figure 53. Metacarpal 3+4, Proximal Surface

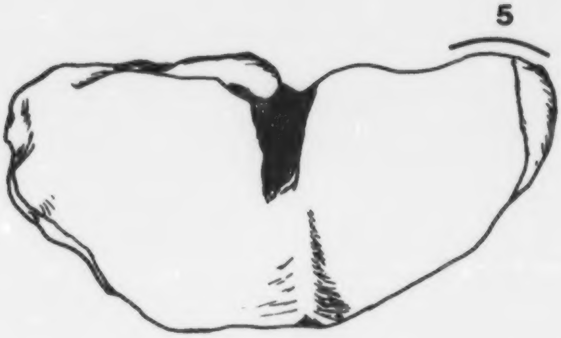
METACARPAL 3+4

Fig. 53. Proximal Surface

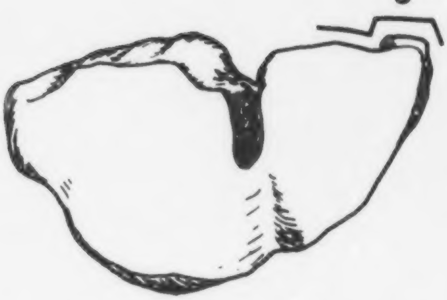
(5) The articulation for metacarpal 5 juts out from the articular surface for carpal 4 in *Bos*, but not in *Bison*.

success rate for *Bison*	15/26 = 57.69%
success rate for *Bos*	8/12 = 66.67%

Character #5: articulation for metacarpal 5	Aspect 1	Aspect 2	Aspect 3
	even	juts out	intermediate
No. of *Bison*	15/26	9/26	2/26
No. of *Bos*	2/12	8/12	2/12
Preference Factor *Bison*	2.94	0.53	0.47
Preference Factor *Bos*	0.34	1.90	2.12



BISON



BOS

Figure 53. Metacarpal 3+4, Proximal Surface

PROXIMAL PHALANX

In both *Bos* and *Bison*, the front proximal phalanges seem rather thick and stubby, while the rear proximal phalanges appear slenderer and slightly longer. (see Figure 54)

Fig. 55. Dorsal View

(1)* The distal two-thirds of the lateral margin is more curved in *Bison*, straighter in *Bos*.

success rate for *Bison*	10/24 = 41.67%
success rate for *Bos*	13/14 = 92.86%

Character #1: lateral margin	Aspect 1	Aspect 2	Aspect 3
	more curved	straighter	intermediate
No. of *Bison*	10/24	6/24	8/24
No. of *Bos*	1/14	13/14	0/14
Preference Factor *Bison*	4.22	0.28	13.66
Preference Factor *Bos*	0.24	3.51	0.07

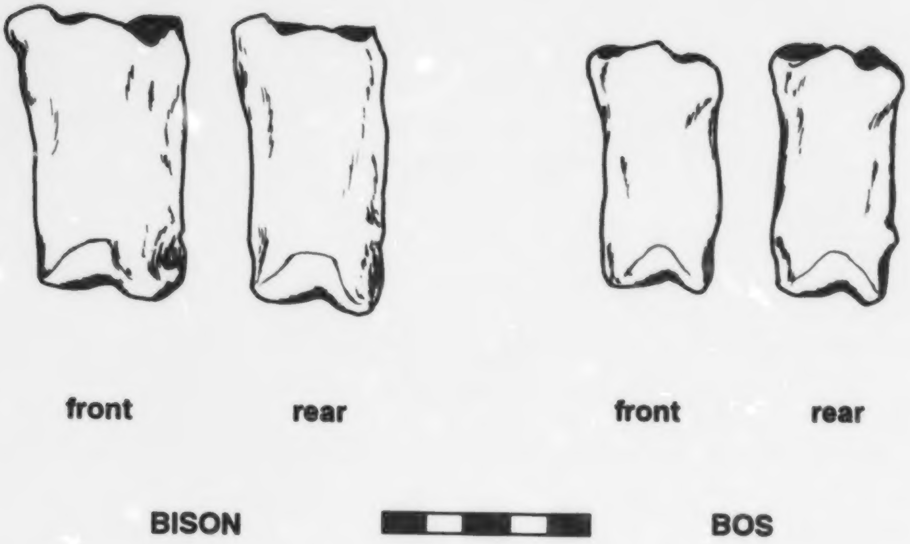

front
rear
front
rear
BISON
BOS

Figure 54. Proximal Phalanges, Dorsal View

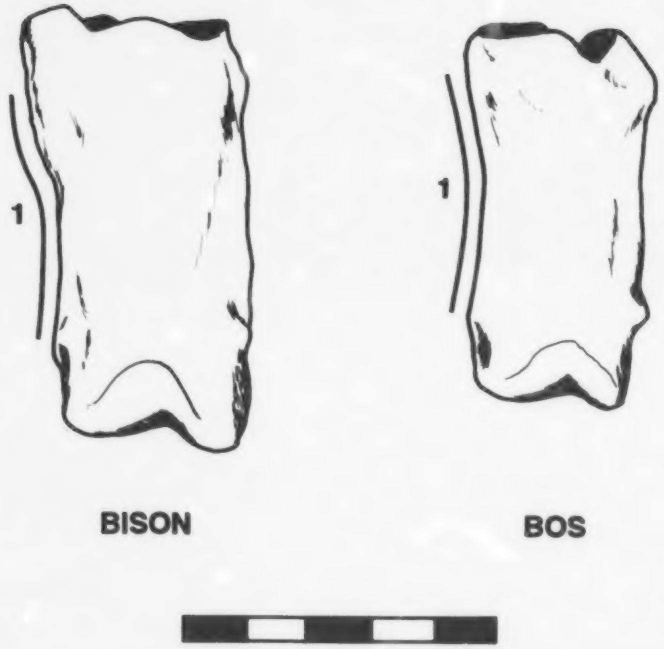

1
1
BISON
BOS

Figure 55. Rear Proximal Phalanx, Dorsal View

PROXIMAL PHALANX

Fig. 56. Plantar View

(2)* *Bison* have a more conspicuous tuberosity on the medial face below the proximal articular surface.

success rate for *Bison*	8/24 = 33.33%
success rate for *Bos*	10/14 = 71.43%

Character #2: tuberosity on medial face	Aspect 1	Aspect 2	Aspect 3
	conspicuous	less obvious	intermediate
No. of *Bison*	8/24	14/24	2/24
No. of *Bos*	2/14	10/14	2/14
Preference Factor *Bison*	2.02	0.82	0.59
Preference Factor *Bos*	0.49	1.22	1.69

(3)* *Bos* have deeper pits on the dorsal face of the proximal end.

success rate for *Bison*	16/24 = 66.67%
success rate for *Bos*	8/14 = 57.14%

Character #3: pits on dorsal face	Aspect 1	Aspect 2	Aspect 3
	shallower	deeper	intermediate
No. of *Bison*	16/24	3/24	5/24
No. of *Bos*	5/14	8/14	1/14
Preference Factor *Bison*	1.78	0.24	2.21
Preference Factor *Bos*	0.56	4.12	0.45

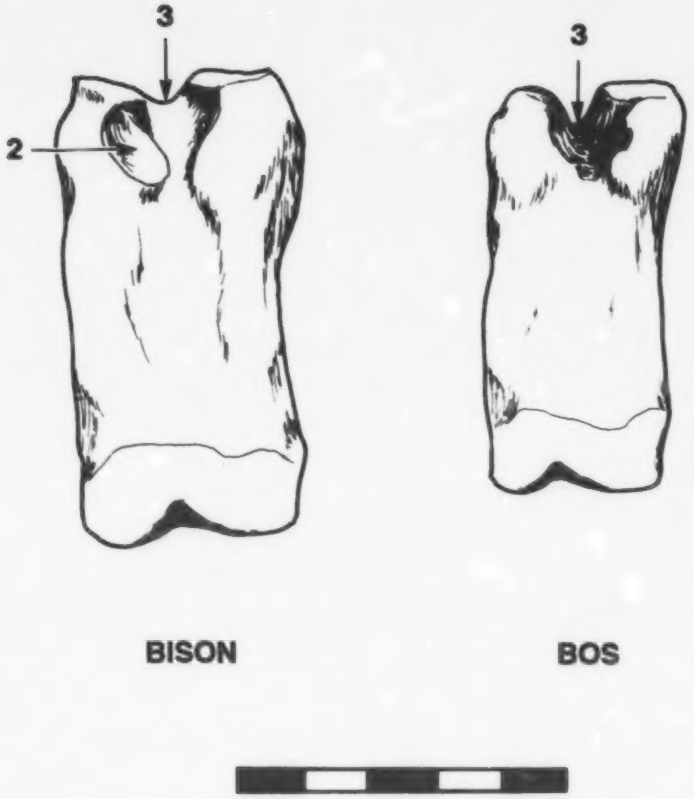

3
2
3
BISON
BOS

Figure 56. Rear Proximal Phalanx, Plantar View

MIDDLE PHALANX

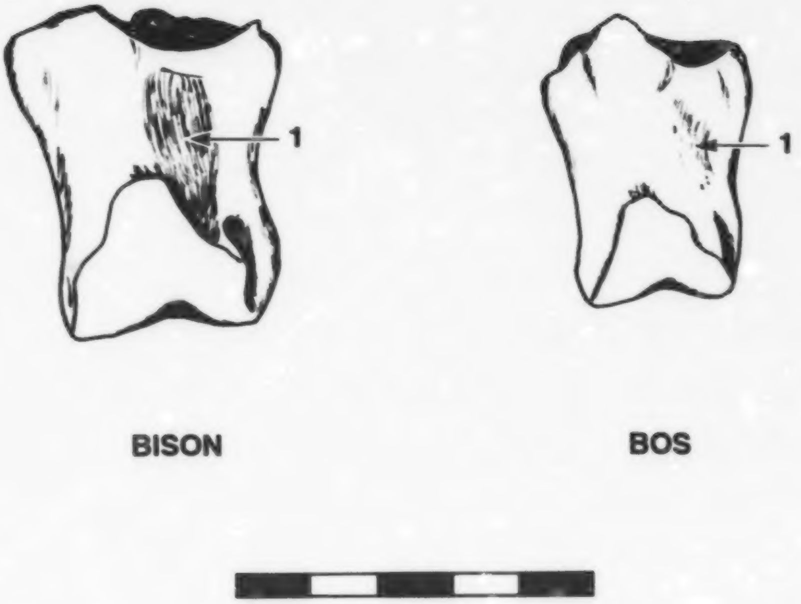
For both *Bos* and *Bison*, the front middle phalanges are short and squat, while the rear appear longer and slenderer (see Fig. 58).

Fig. 57. Dorsal View

(1)* The tendon imprint in the dorsal surface is deeper in *Bison* than in *Bos*. (We find this difference more noticeable when considering the front phalanges rather than the rear).

success rate for *Bison*	11/14 = 78.57%
success rate for *Bos*	10/14 = 71.43%

Character #1: tendon imprint	Aspect 1	Aspect 2	Aspect 3
	deeper	shallower	intermediate
No. of *Bison*	11/14	1/14	2/14
No. of *Bos*	4/14	10/14	0/14
Preference Factor *Bison*	2.56	0.14	6.75
Preference Factor *Bos*	0.39	7.13	0.15



BISON **BOS**

Figure 57. Front Middle Phalanx, Dorsal View

MIDDLE PHALANX

Fig. 58. Lateral View

(2)* *Bison* have a straighter dorsal margin when viewed laterally, while *Bos* appear dished. (Again, we find this distinction more noticeable in the front phalanges than in the rear ones).

success rate for *Bison*	**6/8 = 75.00%
success rate for *Bos*	**7/9 = 77.78%

Character #2: dorsal margin	Aspect 1	Aspect 2	Aspect 3
	straighter	dished	intermediate
No. of *Bison*	6/8	2/8	0/8
No. of *Bos*	1/9	7/9	1/9
Preference Factor *Bison*	4.93	0.37	0.28
Preference Factor *Bos*	0.20	2.70	3.58

** Note that sample sizes are very small.

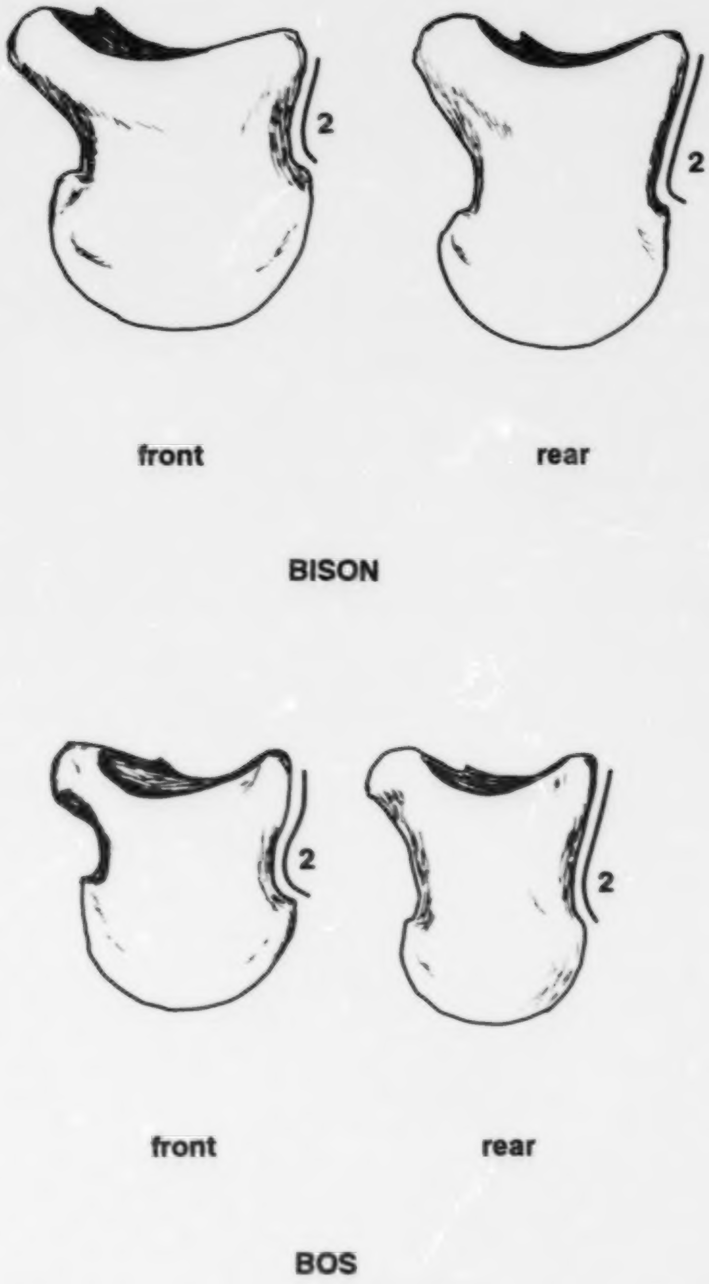

2
2
front
rear
BISON
2
2
front
rear
BOS

Figure 58. Middle Phalanges, Lateral View

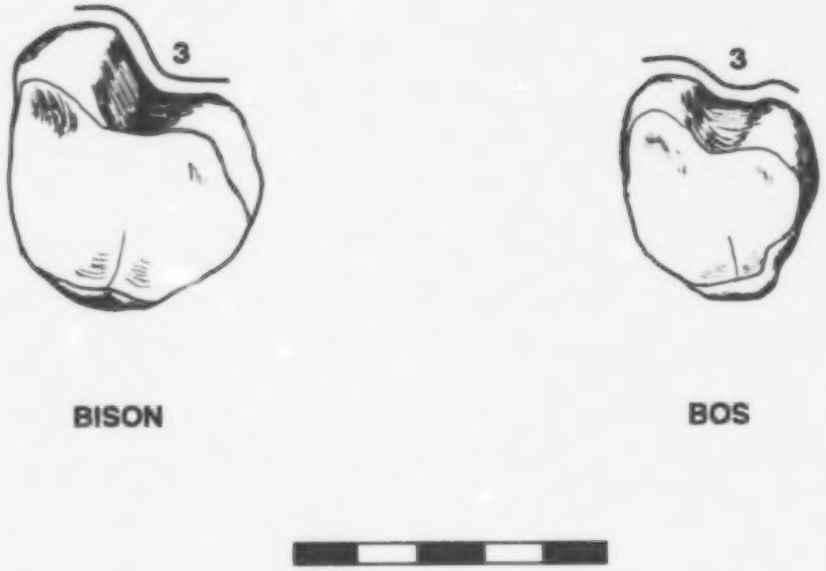
MIDDLE PHALANX

Fig. 59. Proximal Surface

(3) On the proximal surface of the front phalanges, *Bison* show a sharply angled step in the posterior margin, whereas *Bos* have a shallow notch. A similar distinction is apparent in the rear phalanges, but to a lesser extent.

success rate for *Bison*	12/14 = 85.71%
success rate for *Bos*	14/14 = 100.0%

Character #3: posterior margin of proximal surface	Aspect 1	Aspect 2	Aspect 3
	sharply angled step	shallow notch	intermediate
No. of *Bison*	12/14	1/14	1/14
No. of *Bos*	0/14	14/14	0/14
Preference Factor *Bison*	33.97	0.10	4.00
Preference Factor *Bos*	0.03	9.85	0.25



BISON

BOS

Figure 59. Front Middle Phalanx, Proximal Surface

MIDDLE PHALANX

Fig. 60. Lateral View

(4) For the rear phalanges, the distal condyle juts out from the "shaft" more abruptly and to a greater extent in *Bison* than in *Bos*. When examined upside down, this gives the impression of a toadstool in *Bison* but not in *Bos*.

success rate for *Bison*	11/11 = 100.0%
success rate for *Bos*	7/13 = 53.85%

Character #4: impression of toadstool	Aspect 1	Aspect 2	Aspect 3
	yes	no	intermediate
No. of *Bison*	11/11	0/11	0/11
No. of *Bos*	5/13	7/13	1/13
Preference Factor *Bison*	2.46	0.06	0.29
Preference Factor *Bos*	0.41	17.35	3.41

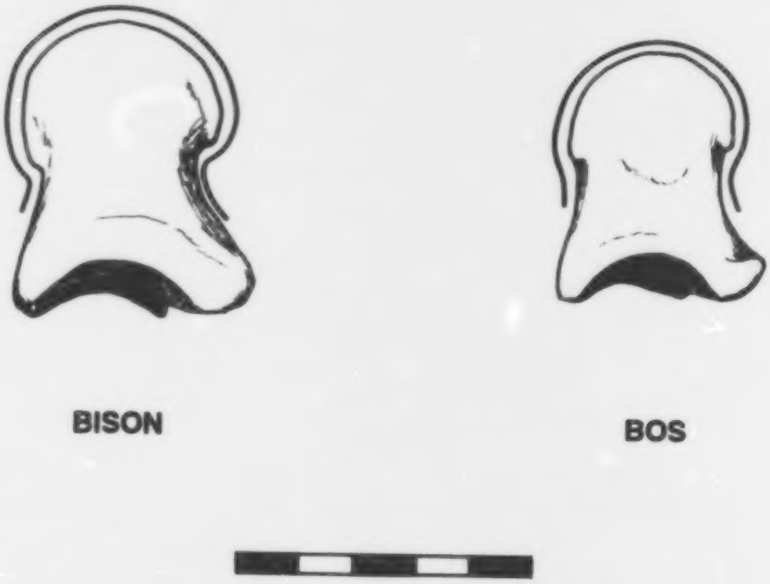


Figure 60. Rear Middle Phalanx, Inverted, Lateral View

DISTAL PHALANX

Fig. 61. Lateral View

(1)* The plantar margin is straighter in *Bison*, more curved in *Bos*.

success rate for *Bison*	11/13 = 84.62%
success rate for *Bos*	9/14 = 64.29%

Character #1: plantar margin	Aspect 1	Aspect 2	Aspect 3
	straighter	more curved	intermediate
No. of *Bison*	11/13	2/13	0/13
No. of *Bos*	5/14	9/14	0/14
Preference Factor *Bison*	2.25	0.28	1.07
Preference Factor *Bos*	0.44	3.56	0.93

(2)* The outer plantar margin and the inner surface below the anterior articular margin is heavily sculptured or deeply eroded in *Bos*, but not in *Bison*. (Not illustrated)

success rate for *Bison*	12/13 = 92.31%
success rate for *Bos*	2/14 = 14.29%

Character #2: outer plantar margin	Aspect 1	Aspect 2	Aspect 3
	smoother	sculptured	intermediate
No. of *Bison*	12/13	1/13	0/13
No. of *Bos*	12/14	2/14	0/14
Preference Factor *Bison*	1.07	0.64	1.07
Preference Factor *Bos*	0.93	1.57	0.93

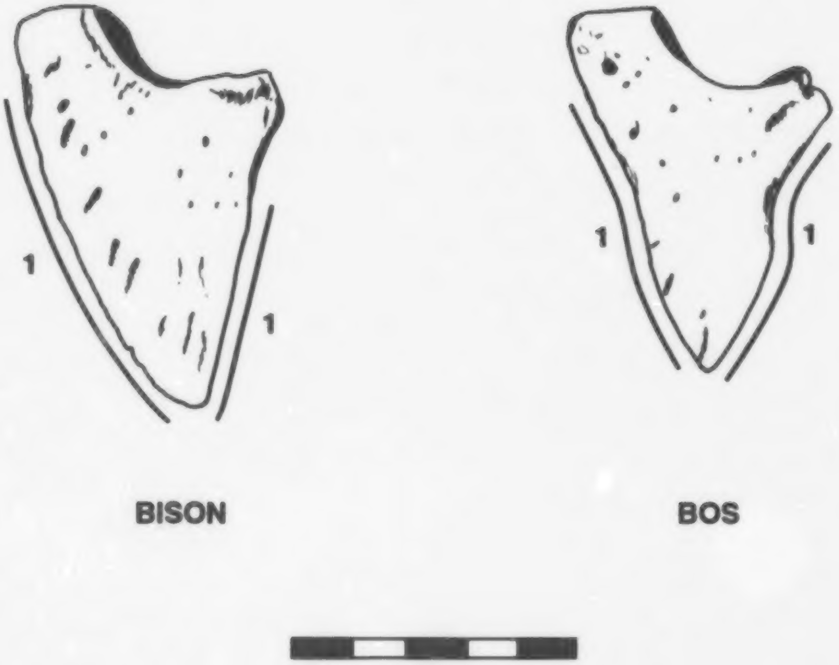

1
1
1
1
BISON
BOS

Figure 61. Rear Distal Phalanx, Lateral View

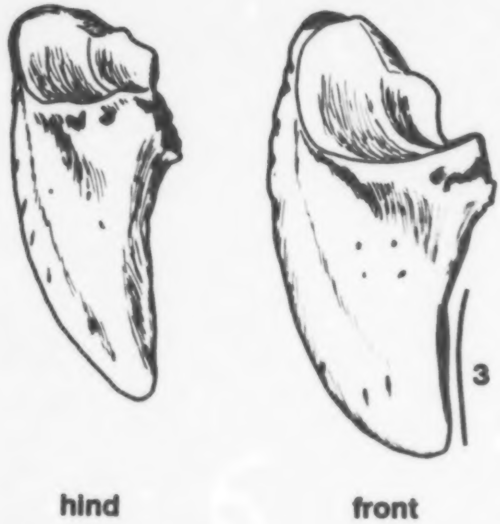
DISTAL PHALANX

Fig. 62. Dorsal View

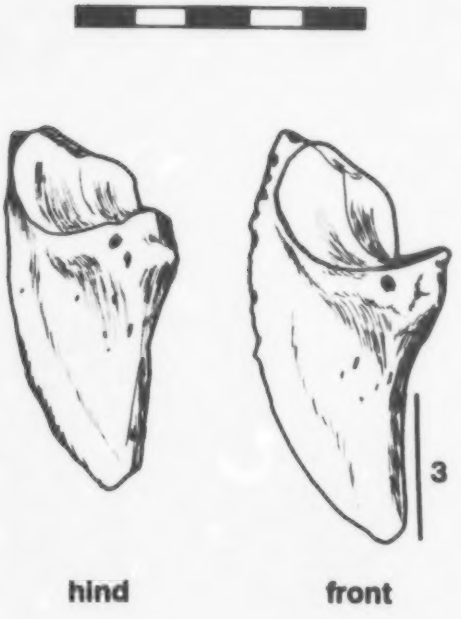
(3)* The inner margin appears concave in *Bison*, convex in *Bos*. (see also Fig. 63).

success rate for *Bison*	10/13 = 76.92%
success rate for *Bos*	13/14 = 92.86%

Character #3: inner margin	Aspect 1	Aspect 2	Aspect 3
	concave	convex	intermediate
No. of *Bison*	10/13	2/13	1/13
No. of *Bos*	1/14	13/14	0/14
Preference Factor *Bison*	7.66	0.20	4.30
Preference Factor *Bos*	0.13	5.06	0.23


3
hind
front

BISON


3
hind
front

BOS

Figure 62. Distal Phalanges, Dorsal View

DISTAL PHALANX

Fig. 63. Proximal Surface

(4) The dorso-posterior corner is broadly rounded in *Bison*, but rises to a steep point in *Bos*. The angle of incline is steeper in *Bos*.

success rate for *Bison*	10/13 = 76.92%
success rate for *Bos*	13/14 = 92.86%

Character #4: dorso-posterior corner	Aspect 1	Aspect 2	Aspect 3
	broadly rounded	rises to steep point	intermediate
No. of *Bison*	10/13	1/13	2/13
No. of *Bos*	1/14	13/14	0/14
Preference Factor *Bison*	7.66	0.12	7.25
Preference Factor *Bos*	0.13	8.54	0.14

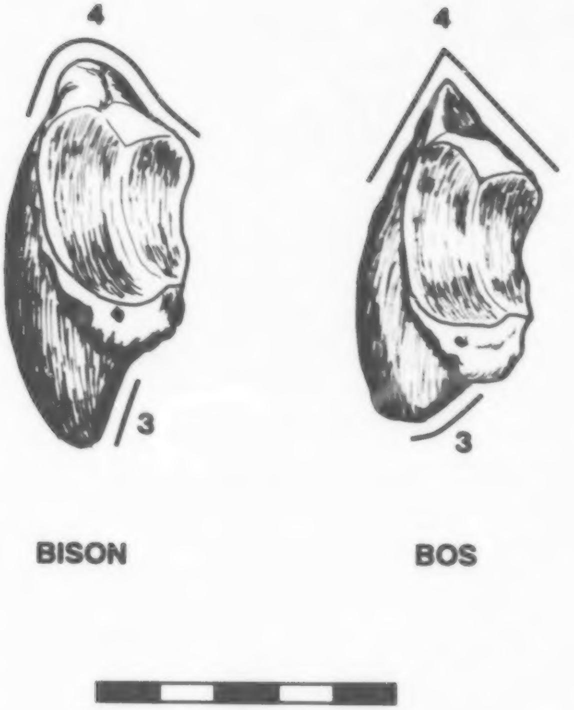

4
3
4
3
BISON
BOS

Figure 63. Rear Distal Phalanx, Proximal Surface

PELVIS

Fig. 64. Lateral View

(1) The tuber sacrale is narrower and rounder in *Bos*, wider and squarer in *Bison*.

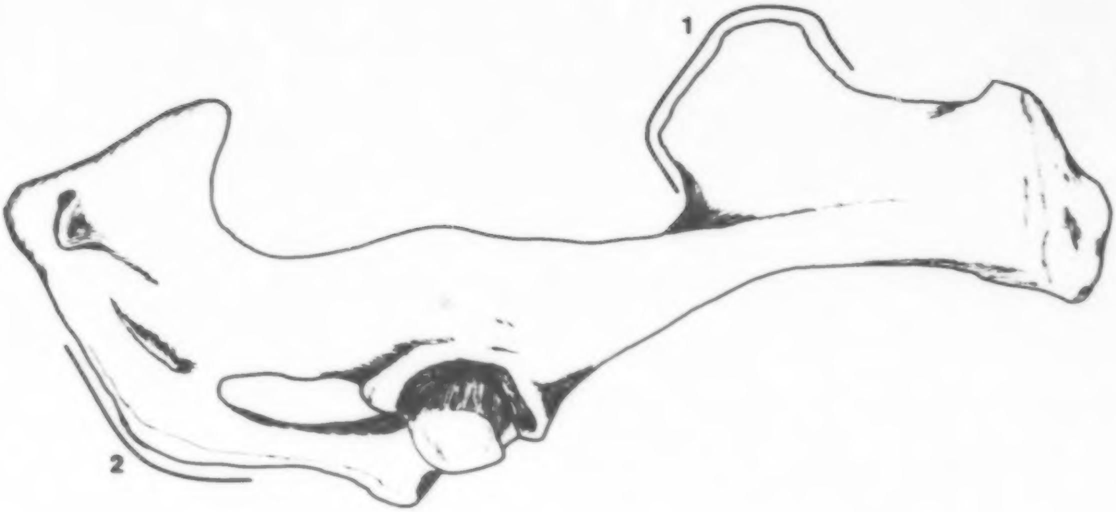
success rate for *Bison*	23/25 = 92.00%
success rate for *Bos*	10/12 = 83.33%

Character #1: shape of tuber sacrale	Aspect 1	Aspect 2	Aspect 3
	wide and square	narrower & rounded	intermediate
No. of *Bison*	23/25	0/25	2/25
No. of *Bos*	2/12	10/12	0/12
Preference Factor *Bison*	5.01	0.02	3.57
Preference Factor *Bos*	0.20	59.04	0.28

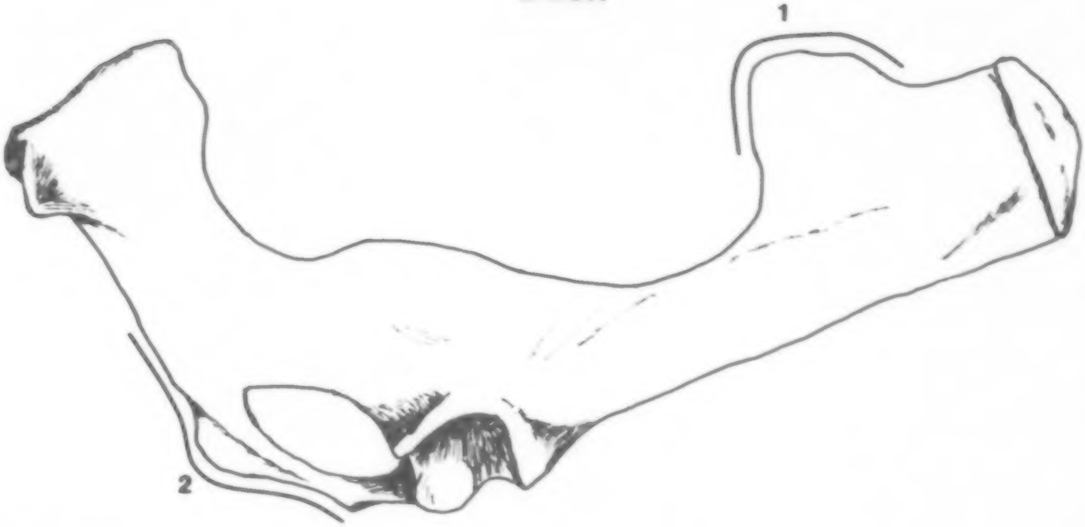
(2) In the middle of the ventral surface the symphyseal ridge terminates posteriorly in a large bump in *Bos*. This ridge is continuous and strongly rounded in *Bison*.

success rate for *Bison*	20/24 = 83.33%
success rate for *Bos*	8/11 = 72.73%

Character #2: symphyseal ridge	Aspect 1	Aspect 2	Aspect 3
	continuous	large bump	intermediate
No. of *Bison*	20/24	2/24	2/24
No. of *Bos*	1/11	8/11	2/11
Preference Factor *Bison*	6.54	0.14	0.47
Preference Factor *Bos*	0.15	7.29	2.13



BISON



BOS

Figure 64. Pelvis, Lateral View

PELVIS

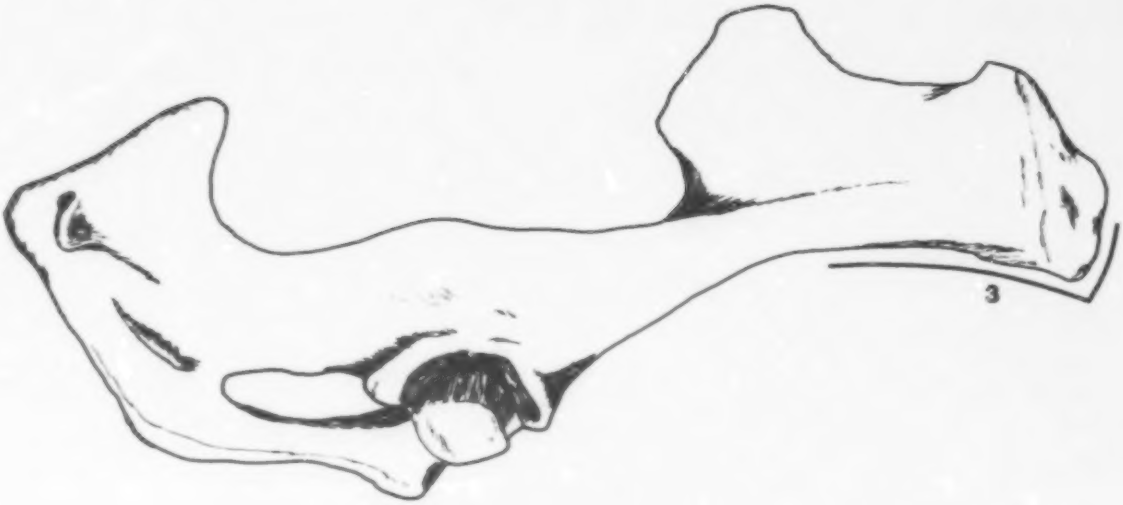
Fig. 64. Lateral View

(3)* The marginal outline of the ilium in the vicinity of the tuber coxae terminates as a rounded point in *Bison*, a very roughened margin in *Bos*.

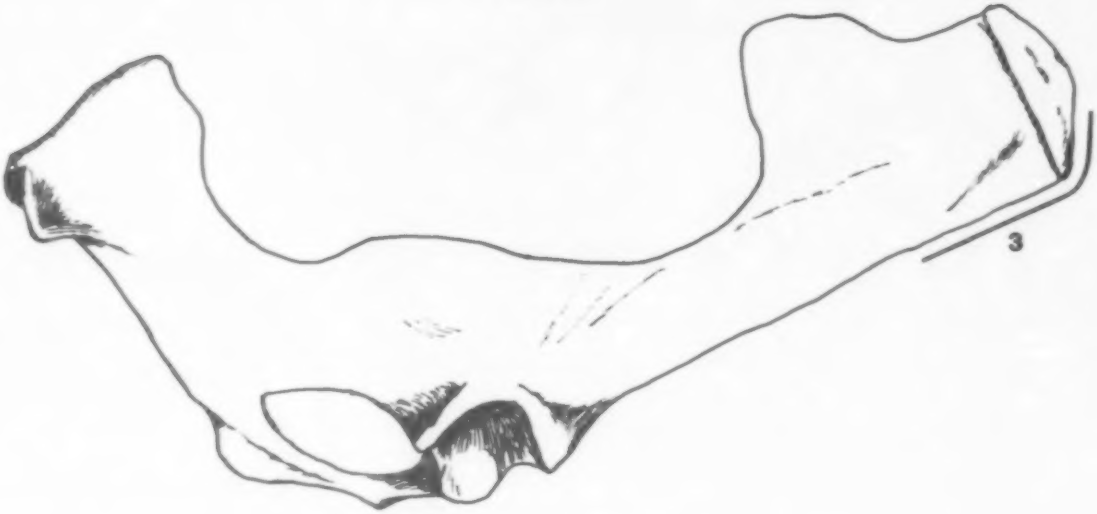
success rate for *Bison*	25/25 = 100.0%
success rate for *Bos*	**2/8 = 25.00%

Character #3: shape of tuber coxae	Aspect 1	Aspect 2	Aspect 3
	rounded point	roughened margin	intermediate
No. of *Bison*	25/25	0/25	0/25
No. of *Bos*	4/8	2/8	2/8
Preference Factor *Bison*	1.89	0.05	0.05
Preference Factor *Bos*	0.53	20.26	20.26

** Note that *Bos* sample size is small.



BISON



BOS

Figure 64. Pelvis, Lateral View

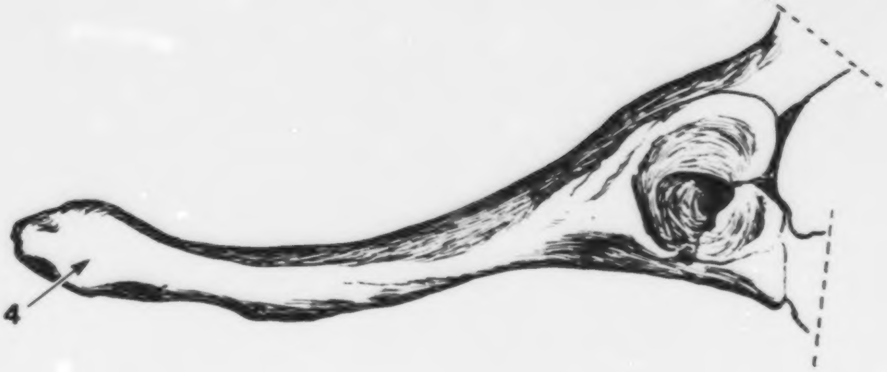
PELVIS

Fig. 65. Ventral View of Tuber Coxae

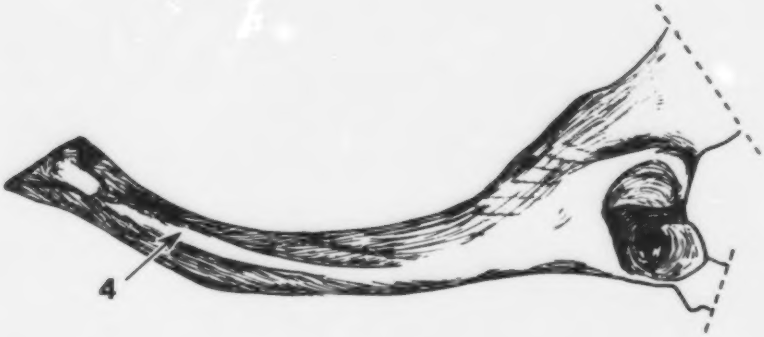
(4) In ventral view the tuber coxae is flattened in *Bison*, sharp-edged in *Bos*.

success rate for *Bison*	24/25 = 96.00%
success rate for *Bos*	7/13 = 53.85%

Character #4: tuber coxae	Aspect 1	Aspect 2	Aspect 3
	flattened	sharp-edged	intermediate
No. of *Bison*	24/25	1/25	0/25
No. of *Bos*	5/13	7/13	1/13
Preference Factor *Bison*	2.36	0.10	0.13
Preference Factor *Bos*	0.42	9.62	7.56



BISON



BOS

Figure 65. Ventral Surface of Tuber Coxae

PELVIS

Fig. 66. Dorsal View

Pubis

(5) The pubis in *Bos* appears narrow, with a strong midline ridge connecting with the ilium. In *Bison* this area is smooth and broad, with no ridge.

success rate for *Bison*	23/24 = 95.83%
success rate for *Bos*	8/13 = 61.54%

Character #5: pubis	Aspect 1	Aspect 2	Aspect 3
	broad, no ridge	narrow, midline ridge	intermediate
No. of *Bison*	23/24	1/24	0/24
No. of *Bos*	5/13	8/13	0/13
Preference Factor *Bison*	2.36	0.10	0.55
Preference Factor *Bos*	0.42	10.48	1.82

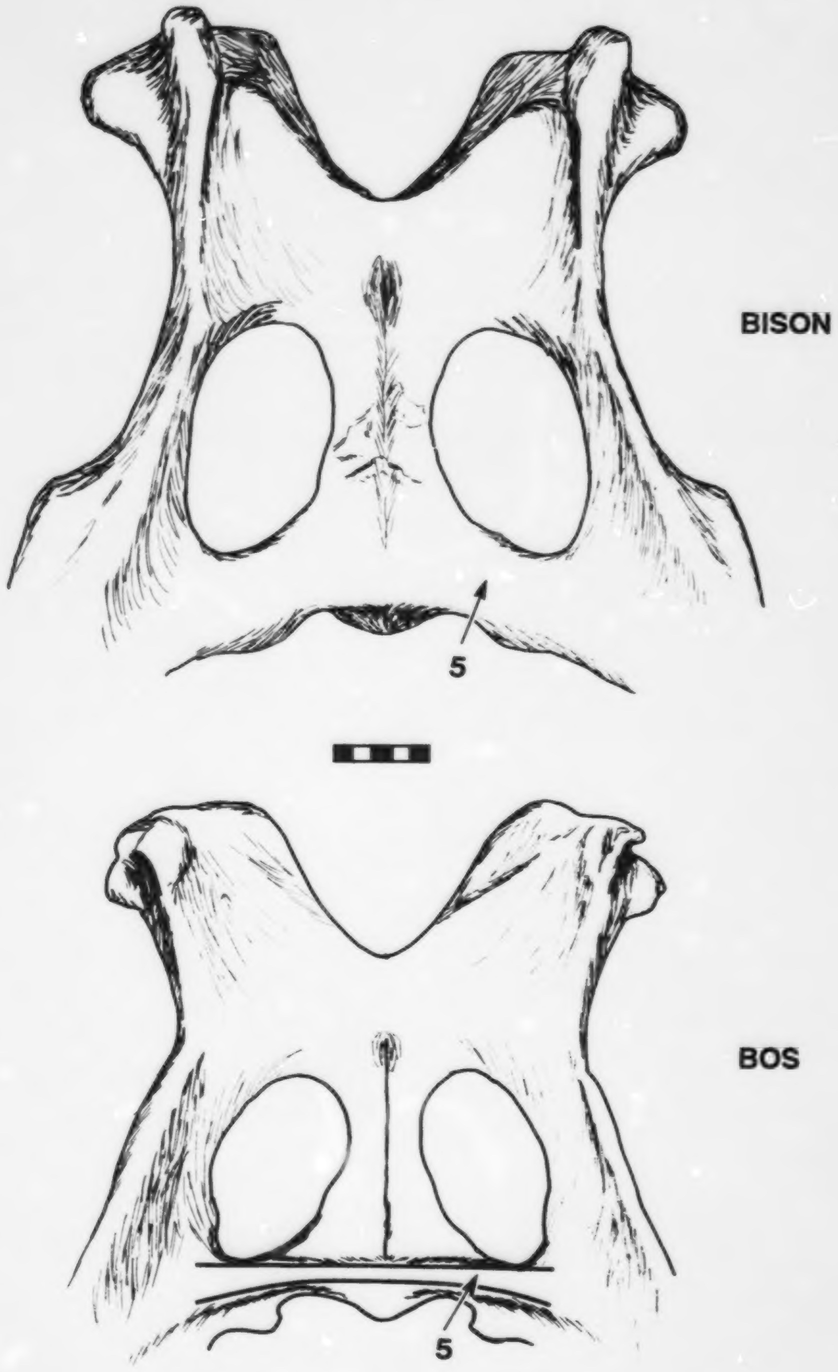

BISON
5
BOS
5

Figure 66. Dorsal View of Pubis and Ischium

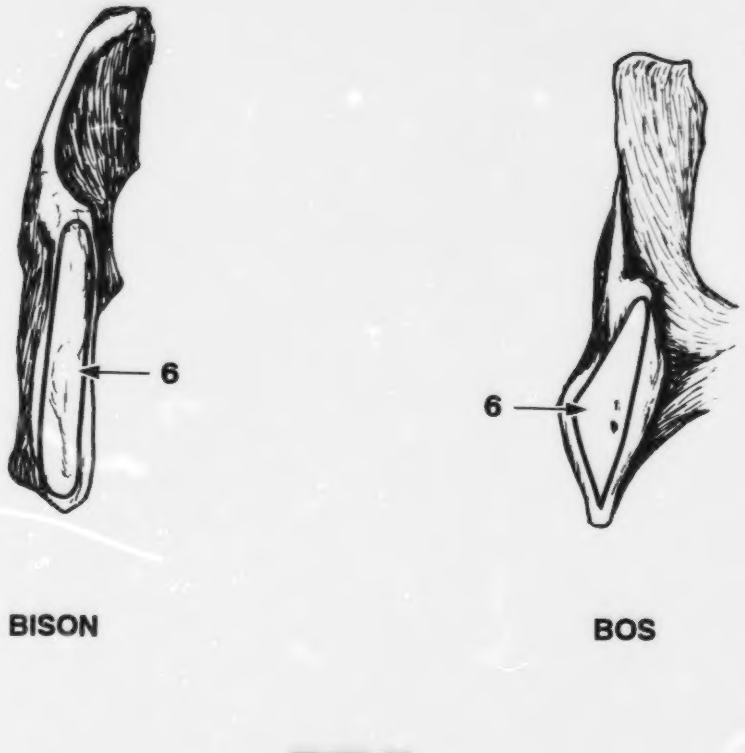
PELVIS

Fig. 67. Anterodorsal View of Tuber Coxae

(6) The tuber coxae is rather triangular in outline in *Bos*, an elongated oval in *Bison*.

success rate for *Bison*	25/25 = 100.0%
success rate for *Bos*	9/13 = 69.23%

Character #6: shape of tuber coxae	Aspect 1	Aspect 2	Aspect 3
	oval	triangular	intermediate
No. of *Bison*	25/25	0/25	0/25
No. of *Bos*	3/13	9/13	1/13
Preference Factor *Bison*	3.87	0.02	0.13
Preference Factor *Bos*	0.26	48.76	7.56



BISON

BOS

Figure 67. Anterodorsal View of Tuber Coxae

FEMUR

Fig. 68. Proximal Femur, Posterior View

(1)* There is a noticeable ridge between the head and the trochanter minor in *Bos* but not in *Bison*.

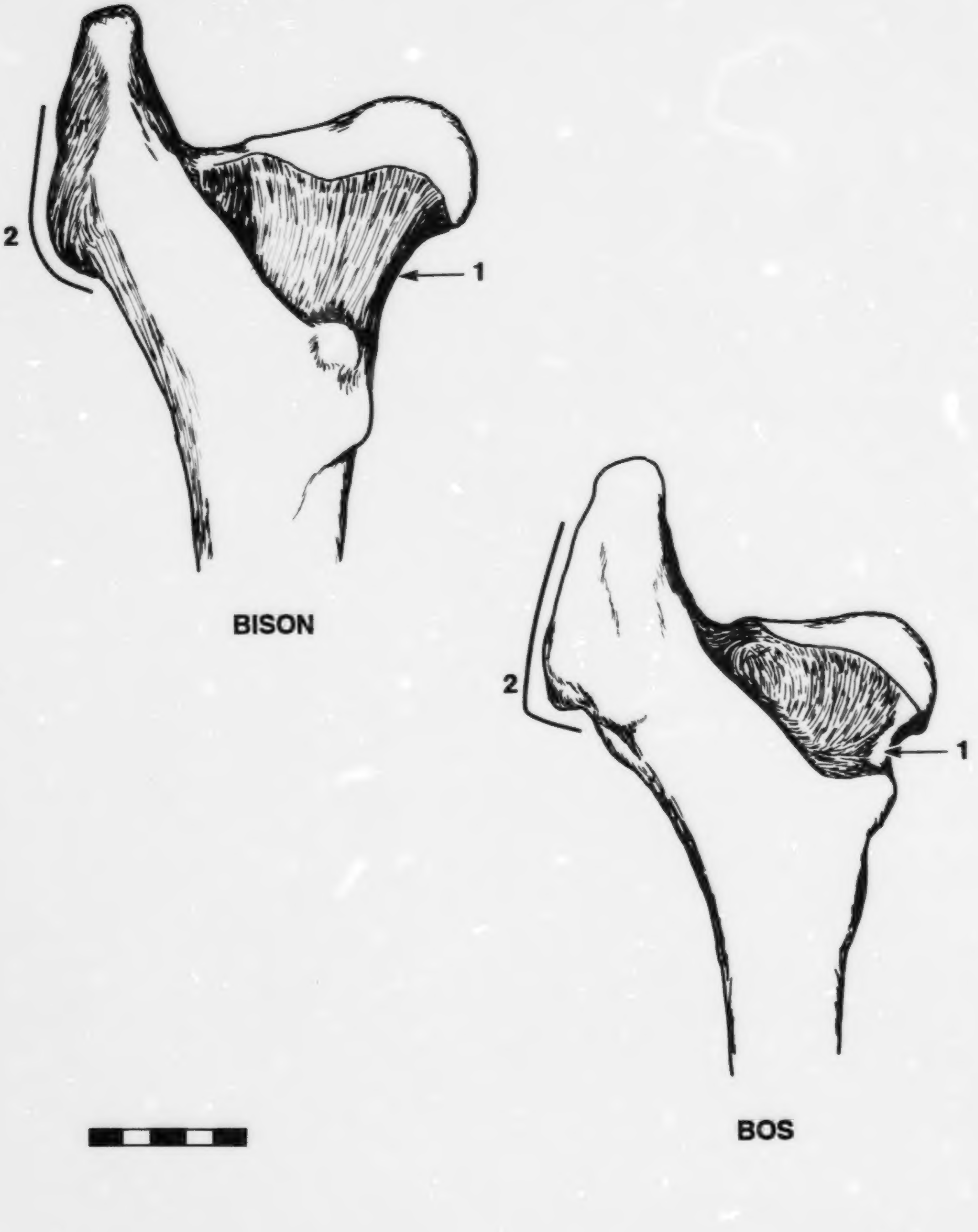
success rate for *Bison*	22/28 = 78.57%
success rate for *Bos*	13/16 = 81.25%

Character #1: ridge from head to trochanter minor	Aspect 1	Aspect 2	Aspect 3
	absent	present	intermediate
No. of *Bison*	22/28	2/28	4/28
No. of *Bos*	1/16	13/16	2/16
Preference Factor *Bison*	8.85	0.11	1.05
Preference Factor *Bos*	0.11	9.39	0.96

(2)* The trochanter major projects laterally to a greater extent in *Bos* than in *Bison*.

success rate for *Bison*	26/28 = 92.86%
success rate for *Bos*	15/16 = 93.75%

Character #2: projection of trochanter major	Aspect 1	Aspect 2	Aspect 3
	lesser	greater	intermediate
No. of *Bison*	26/28	2/28	0/28
No. of *Bos*	0/16	15/16	1/16
Preference Factor *Bison*	41.70	0.09	0.14
Preference Factor *Bos*	0.02	10.78	6.91



BISON

BOS

Figure 68. Proximal Femur, Posterior View

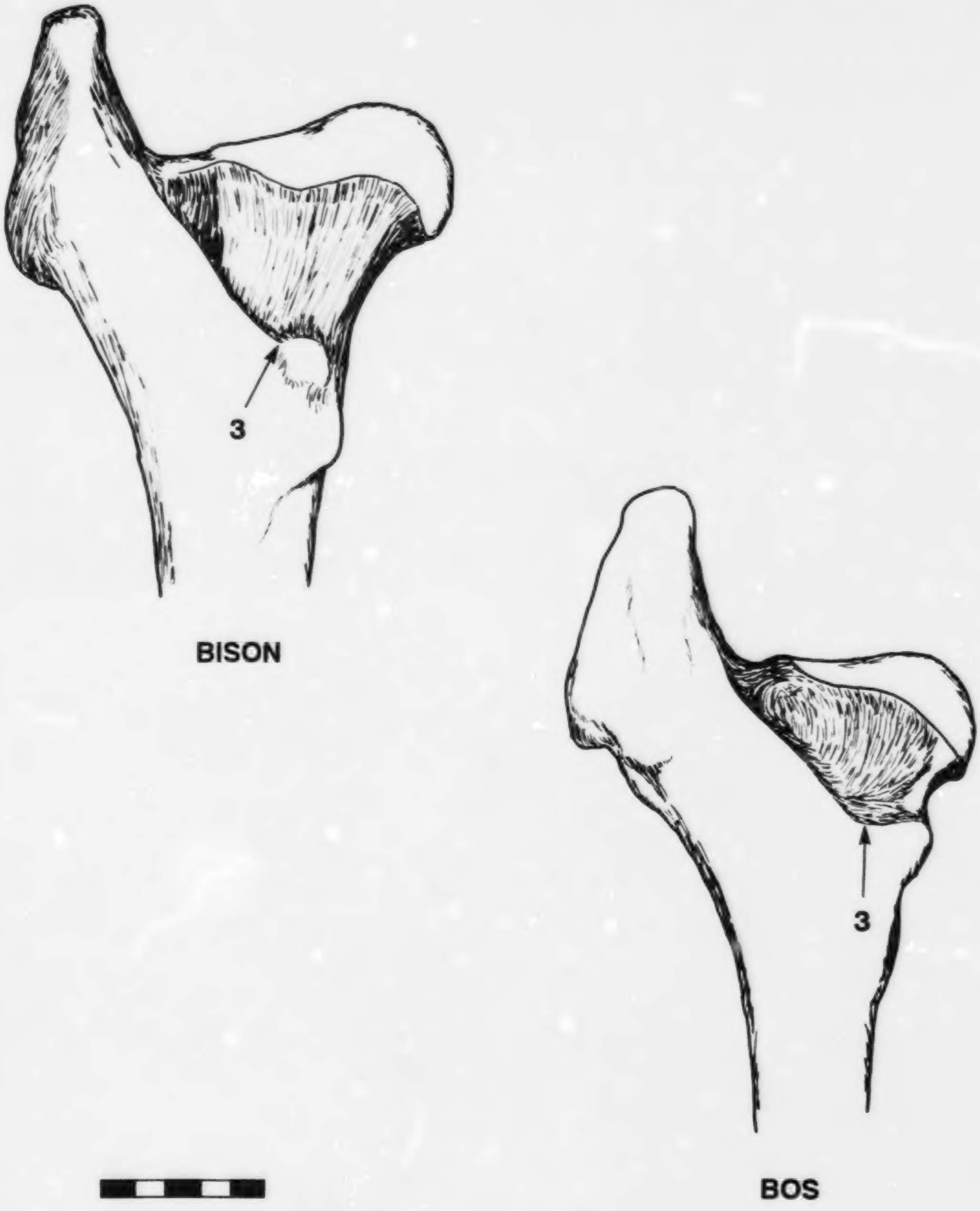
FEMUR

Fig. 68. Proximal Femur, Posterior View

(3) The intertrochanteric crest in *Bos* is continuous from the trochanter major to the trochanter minor, terminating with a flattened shelf-like area just above the trochanter minor. In *Bison* this same crest stops short of the trochanter minor with no flat shelf at the terminus.

success rate for *Bison*	25/26 = 96.15%
success rate for *Bos*	5/14 = 35.71%

Character #3: intertrochanteric crest	Aspect 1	Aspect 2	Aspect 3
	stops short	continuous	intermediate
No. of *Bison*	25/26	0/26	1/26
No. of *Bos*	8/14	5/14	1/14
Preference Factor *Bison*	1.64	0.04	0.55
Preference Factor *Bos*	0.61	27.29	1.83



BISON

BOS

Figure 68. Proximal Femur, Posterior View

FEMUR

Fig. 69. Proximal Femur, Anterior View

(4)* The head of the femur in *Bison* forms a lip at its junction with the neck; in *Bos* the head blends smoothly into the neck.

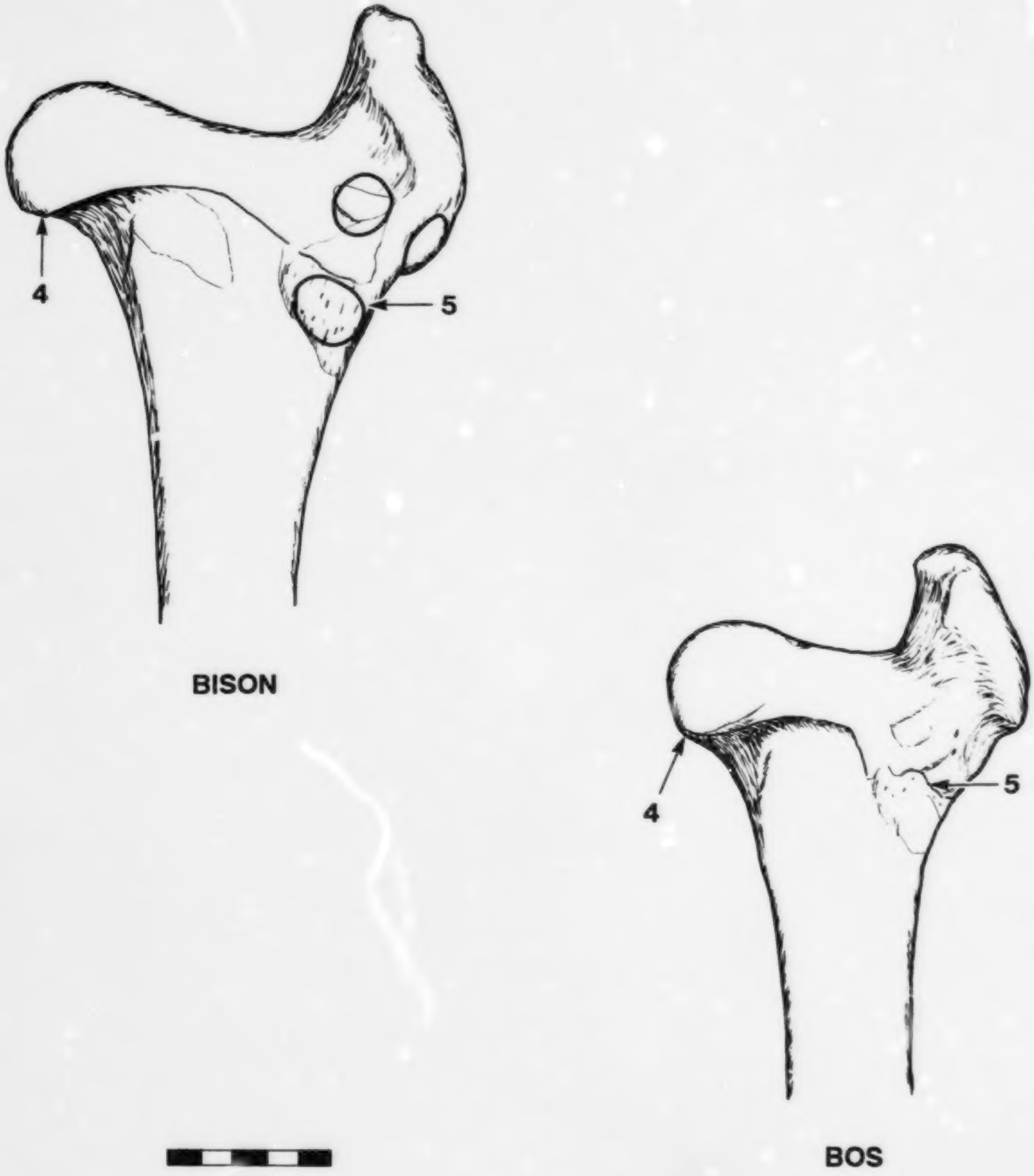
success rate for *Bison*	20/28 = 71.43%
success rate for *Bos*	11/16 = 68.75%

Character #4: head-neck junction	Aspect 1	Aspect 2	Aspect 3
	lipped	smooth	intermediate
No. of *Bison*	20/28	6/28	2/28
No. of *Bos*	4/16	11/16	1/16
Preference Factor *Bison*	2.64	0.33	0.98
Preference Factor *Bos*	0.38	3.06	1.02

(5)* The complex of proximal anterior muscle scars is distinct and separate in *Bison*, fused or closely grouped in *Bos*.

success rate for *Bison*	17/25 = 68.00%
success rate for *Bos*	4/13 = 30.77%

Character #5: complex of muscle scars	Aspect 1	Aspect 2	Aspect 3
	distinct and separate	fused/closely grouped	intermediate
No. of *Bison*	17/25	4/25	4/25
No. of *Bos*	8/13	4/13	1/13
Preference Factor *Bison*	1.09	0.53	1.62
Preference Factor *Bos*	0.92	1.89	0.62



BISON

BOS

Figure 69. Proximal Femur, Anterior View

FEMUR

Fig. 69. Proximal Femur, Anterior View

(6) In anterior view, the fusion line at the juncture of the head and trochanter major forms a smooth curve in *Bison*, whereas in *Bos* it approaches a right angle.

success rate for *Bison*	21/28 = 75.00%
success rate for *Bos*	10/16 = 62.50%

Character #6: fusion line at juncture	Aspect 1	Aspect 2	Aspect 3
	smooth curve	right angle	intermediate
No. of *Bison*	21/28	5/28	2/28
No. of *Bos*	5/16	10/16	1/16
Preference Factor *Bison*	2.27	0.30	0.98
Preference Factor *Bos*	0.44	3.30	1.02

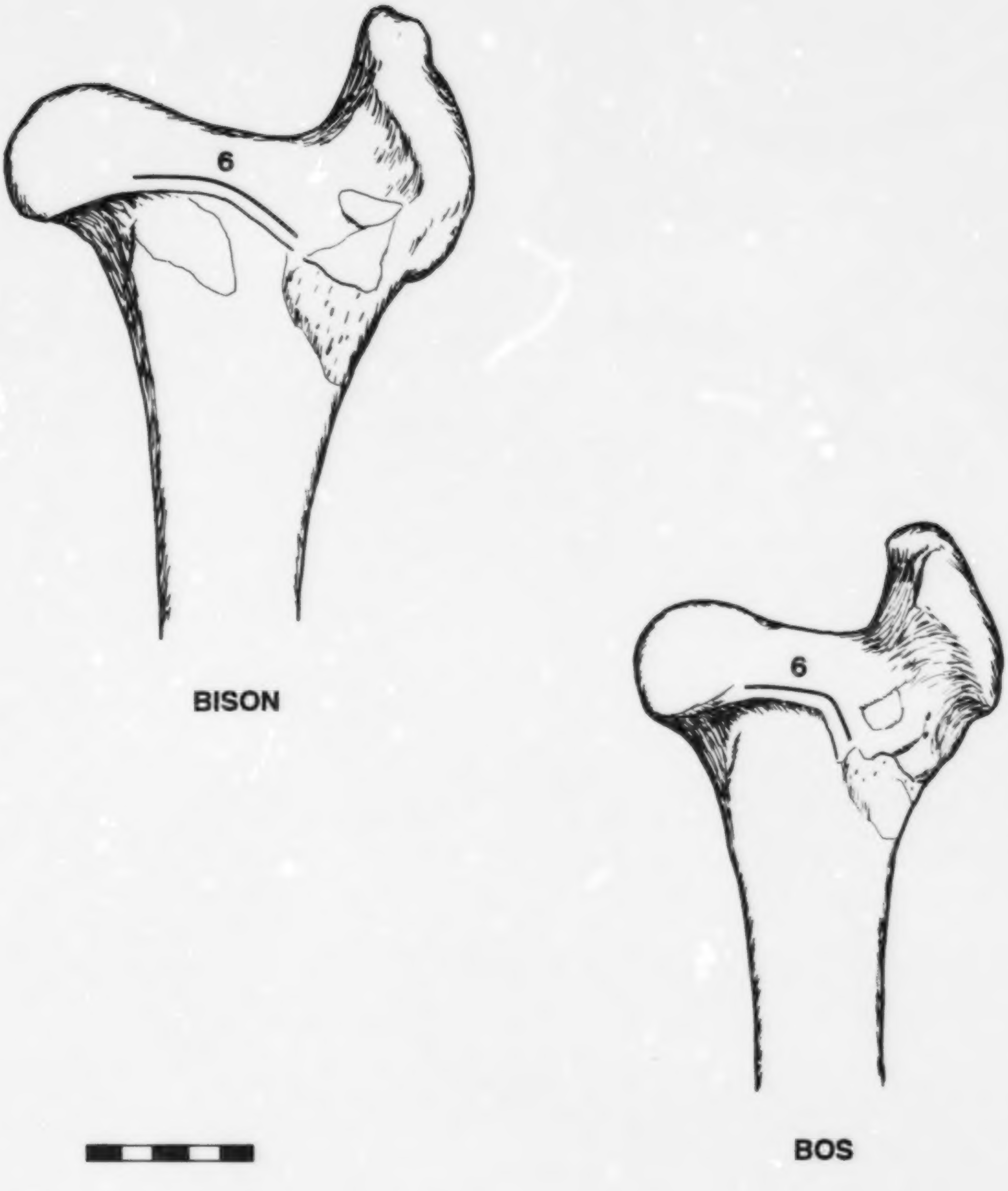

6
BISON
6
BOS

Figure 69. Proximal Femur, Anterior View

FEMUR

Fig. 70. Proximal Femur, Lateral View

(7) The anterior margin of the trochanter major in *Bos* projects almost at a right angle. In *Bison* the anterior margin forms a smoother curve.

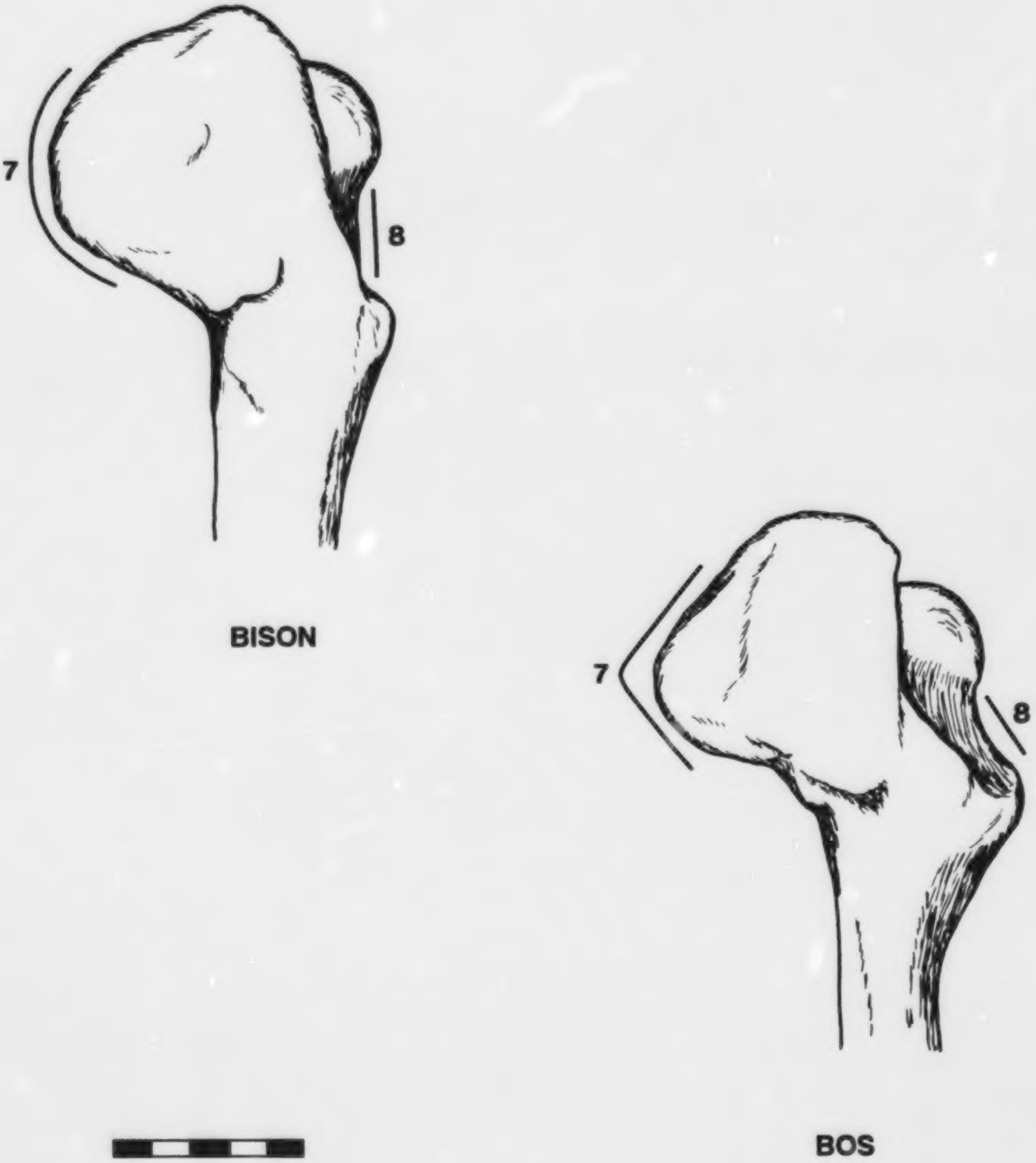
success rate for *Bison*	24/28 = 85.71%
success rate for *Bos*	15/16 = 93.75%

Character #7: trochanter major projection	Aspect 1	Aspect 2	Aspect 3
	smooth curve	right angle	intermediate
No. of *Bison*	24/28	3/28	1/28
No. of *Bos*	1/16	15/16	0/16
Preference Factor *Bison*	9.64	0.13	2.32
Preference Factor *Bos*	0.10	7.68	0.43

(8) The "neck" (from the head to the trochanter minor) is more nearly vertical in *Bison* and appears longer.

success rate for *Bison*	28/28 = 100.0%
success rate for *Bos*	11/16 = 68.75%

Character #8: "neck"	Aspect 1	Aspect 2	Aspect 3
	longer; almost vertical	shorter; less vertical	intermediate
No. of *Bison*	28/28	0/28	0/28
No. of *Bos*	4/16	11/16	1/16
Preference Factor *Bison*	3.67	0.02	0.14
Preference Factor *Bos*	0.27	53.98	6.91


BISON

BOS

Figure 70. Proximal Femur, Lateral View

FEMUR

Fig. 70. Proximal Femur, Lateral View

(9) The trochanter minor is more protuberant in *Bos* than in *Bison*, so that the antero-posterior depth at the trochanter minor is relatively greater in *Bos*.

success rate for *Bison*	22/25 = 88.00%
success rate for *Bos*	7/13 = 53.85%

Character #9: trochanter minor	Aspect 1	Aspect 2	Aspect 3
	protrudes less	protrudes more	intermediate
No. of *Bison*	22/25	1/25	2/25
No. of *Bos*	4/13	7/13	2/13
Preference Factor *Bison*	2.65	0.10	0.53
Preference Factor *Bos*	0.38	9.62	1.89

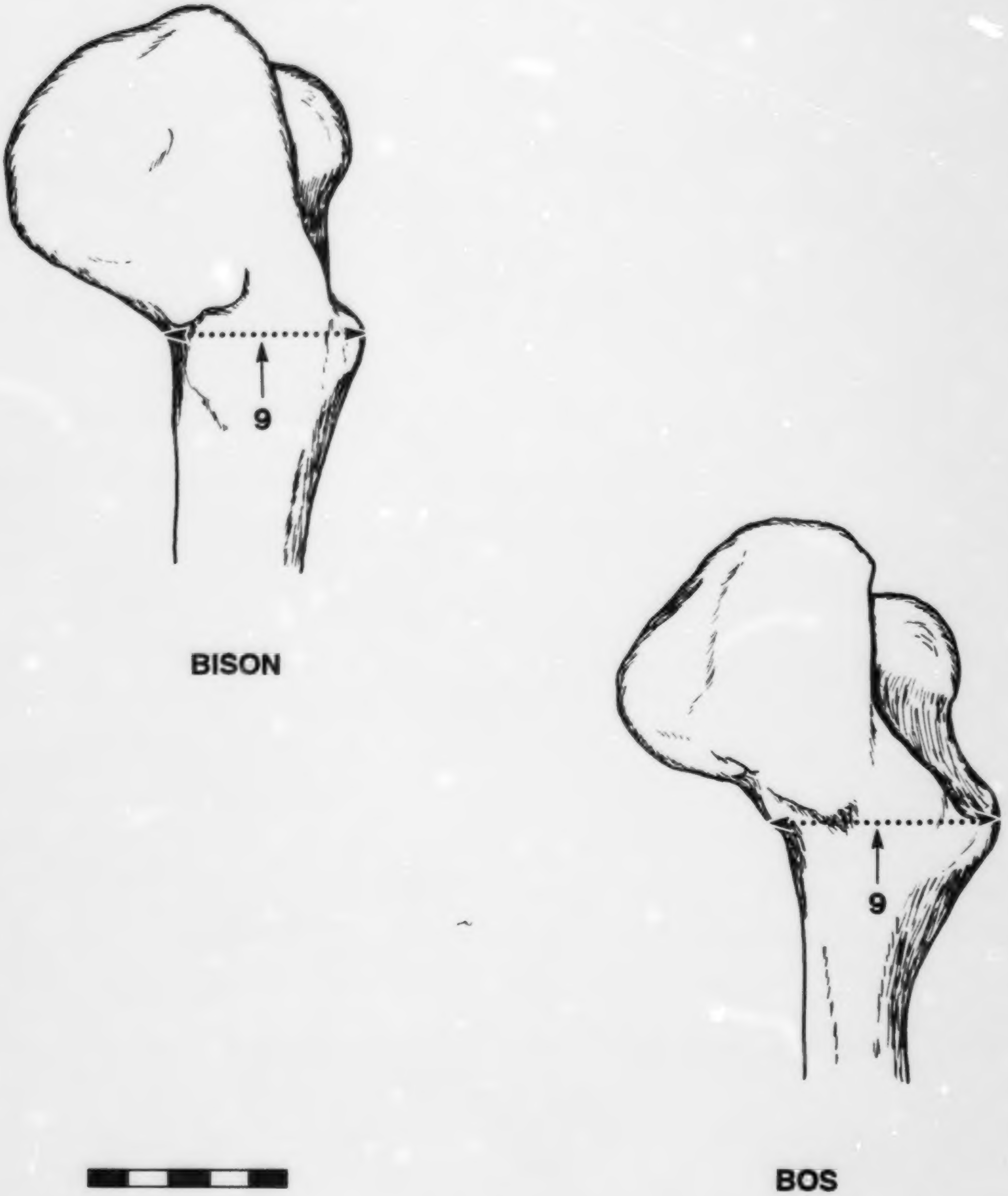

9
BISON
9
BOS

Figure 70. Proximal Femur, Lateral View

FEMUR

Fig. 71. Dorsal View

(10) The anterior margin is indented behind the head in *Bison*, straighter in *Bos*.

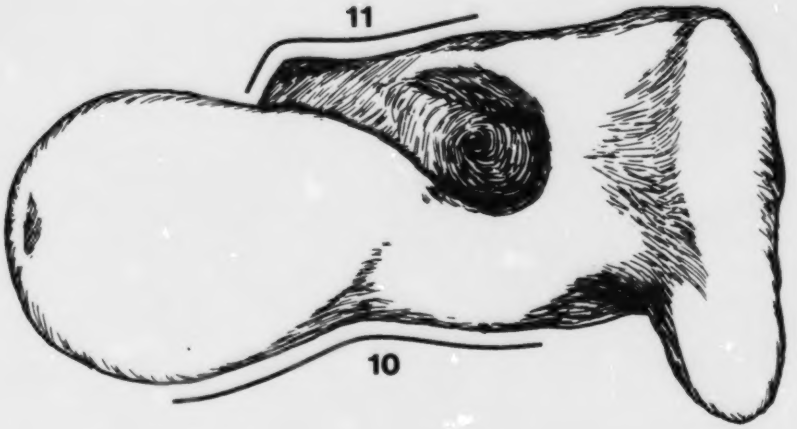
success rate for *Bison*	25/28 = 89.29%
success rate for *Bos*	14/16 = 87.50%

Character #10: anterior margin	Aspect 1	Aspect 2	Aspect 3
	indented	straighter	intermediate
No. of *Bison*	25/28	2/28	1/28
No. of *Bos*	1/16	14/16	1/16
Preference Factor *Bison*	10.03	0.10	0.58
Preference Factor *Bos*	0.10	10.09	1.73

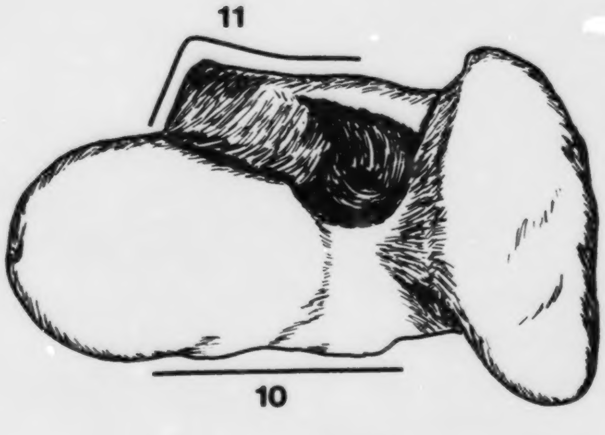
(11) The trochanter minor in *Bos* is closer to the medial surface of the head and it projects posteriorly to a greater degree than in *Bison*, with the result that more of the trochanteric fossa is visible in *Bos* than in *Bison*.

success rate for *Bison*	26/27 = 96.30%
success rate for *Bos*	14/15 = 93.33%

Character #11: trochanteric fossa visible	Aspect 1	Aspect 2	Aspect 3
	less	more	intermediate
No. of *Bison*	26/27	1/27	0/27
No. of *Bos*	1/15	14/15	0/15
Preference Factor *Bison*	10.15	0.06	0.56
Preference Factor *Bos*	0.10	17.48	1.77



BISON



BOS

Figure 71. Femur, Dorsal View

FEMUR

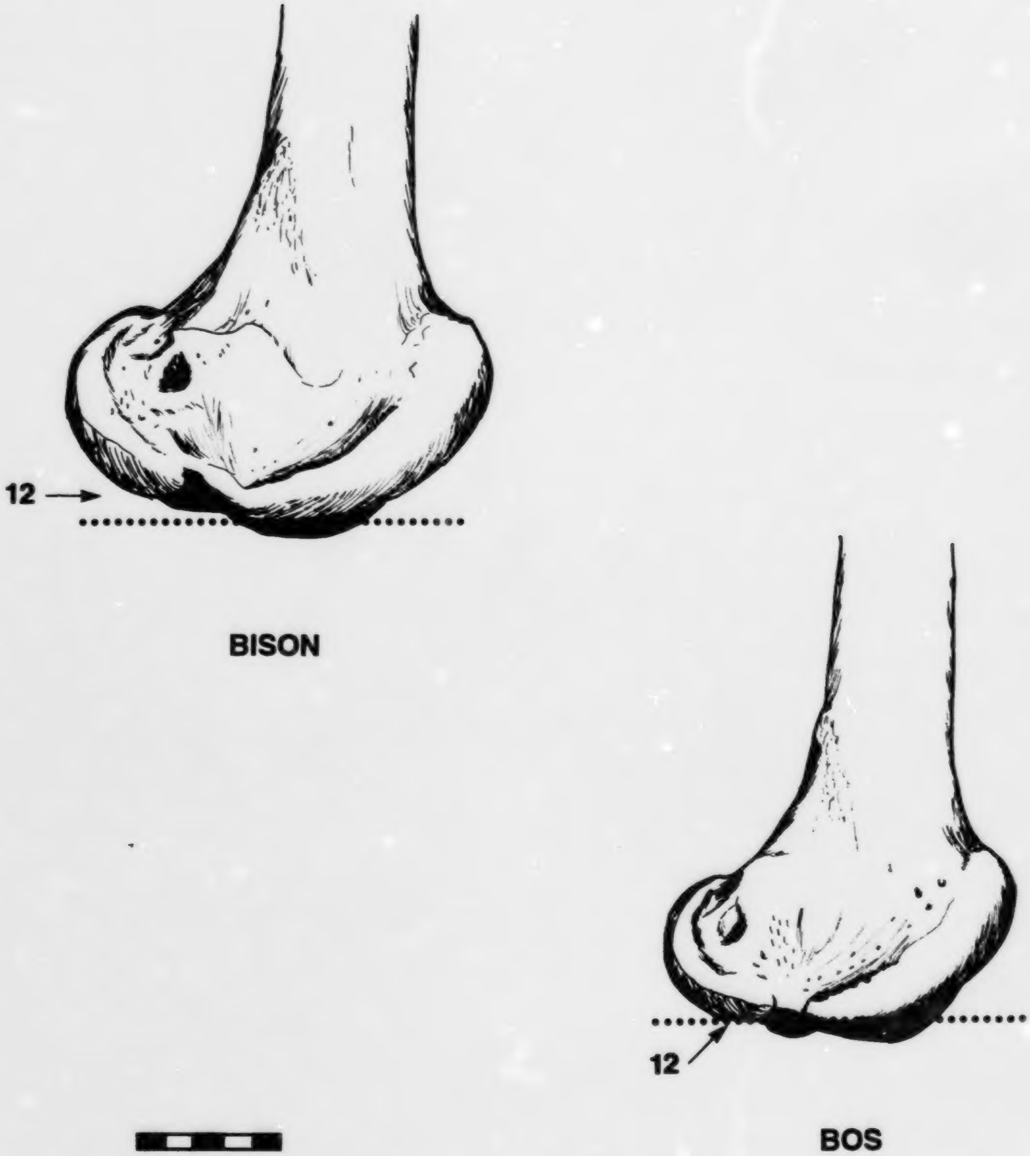
Fig. 72. Distal Femur, Medial View

(12)* The medial condyle and the medial patellar ridge extend the same length distally in *Bos*; the medial condyle is higher in *Bison*.

success rate for *Bison*	12/17 = 70.59%
success rate for *Bos*	**6/8 = 75.00%

Character #12: condyle and patellar ridge	Aspect 1	Aspect 2	Aspect 3
	condyle higher	extend same length	intermediate
No. of *Bison*	12/17	1/17	4/17
No. of *Bos*	2/8	6/8	0/8
Preference Factor *Bison*	2.44	0.11	5.93
Preference Factor *Bos*	0.41	9.09	0.17

** Note that the *Bos* sample size is small.



BISON

BOS

Figure 72. Distal Femur, Medial View

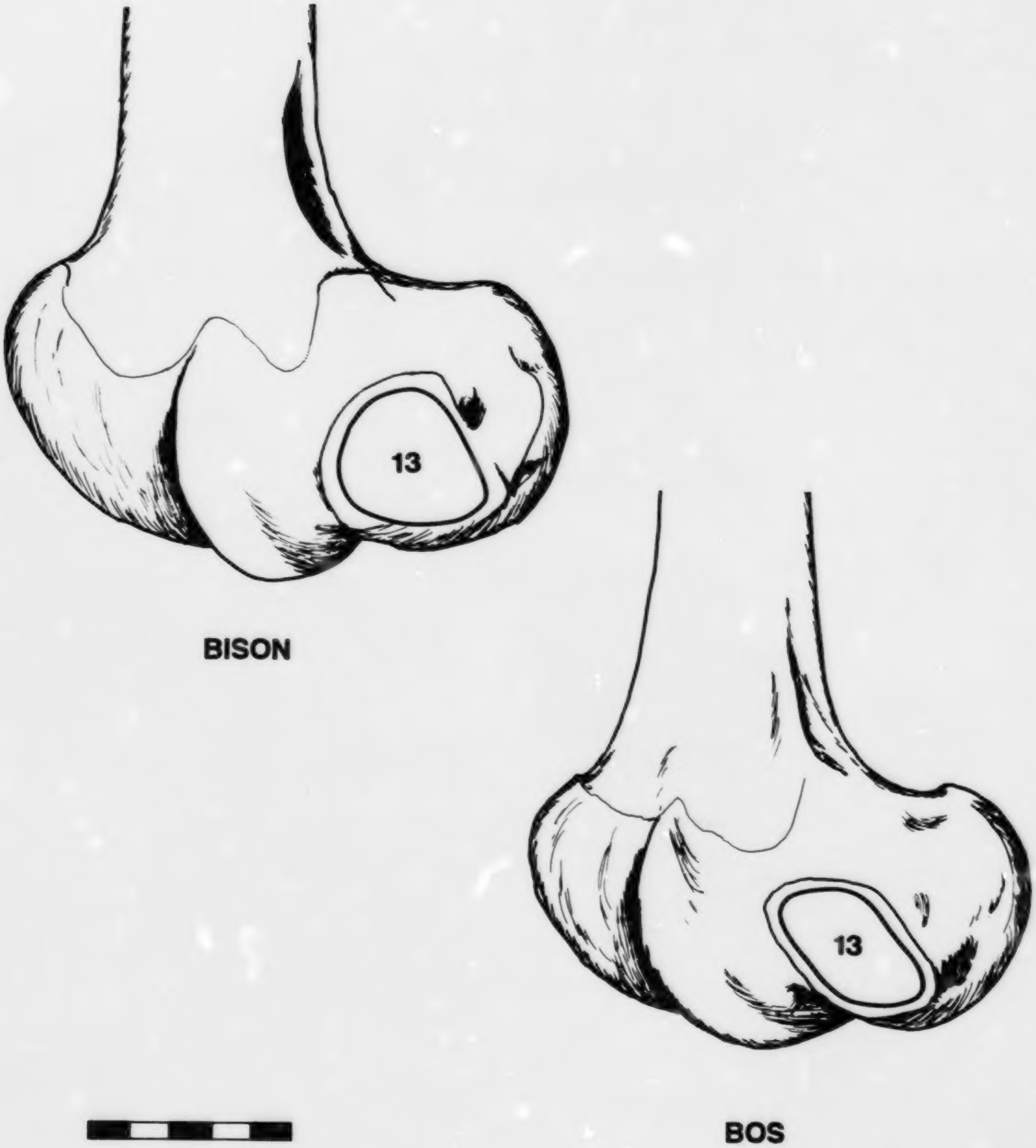
FEMUR

Fig. 73. Distal Femur, Lateral View

(13) The shape of the prominent muscle scar on the lateral condyle is circular to squarish in *Bison*, rectangular to oval in *Bos*.

success rate for *Bison*	22/27 = 81.48%
success rate for *Bos*	11/13 = 84.62%

Character #13: muscle scar on condyle	Aspect 1	Aspect 2	Aspect 3
	circular to squarish	rectangular to oval	intermediate
No. of *Bison*	22/27	3/27	2/27
No. of *Bos*	1/13	11/13	1/13
Preference Factor *Bison*	7.50	0.15	0.83
Preference Factor *Bos*	0.13	6.72	1.21



BISON

BOS

Figure 73. Distal Femur, Lateral View

FEMUR

Fig. 73. Distal Femur, Lateral View

(14) The supracondyloid fossa appears relatively deeper in *Bison* than in *Bos*.

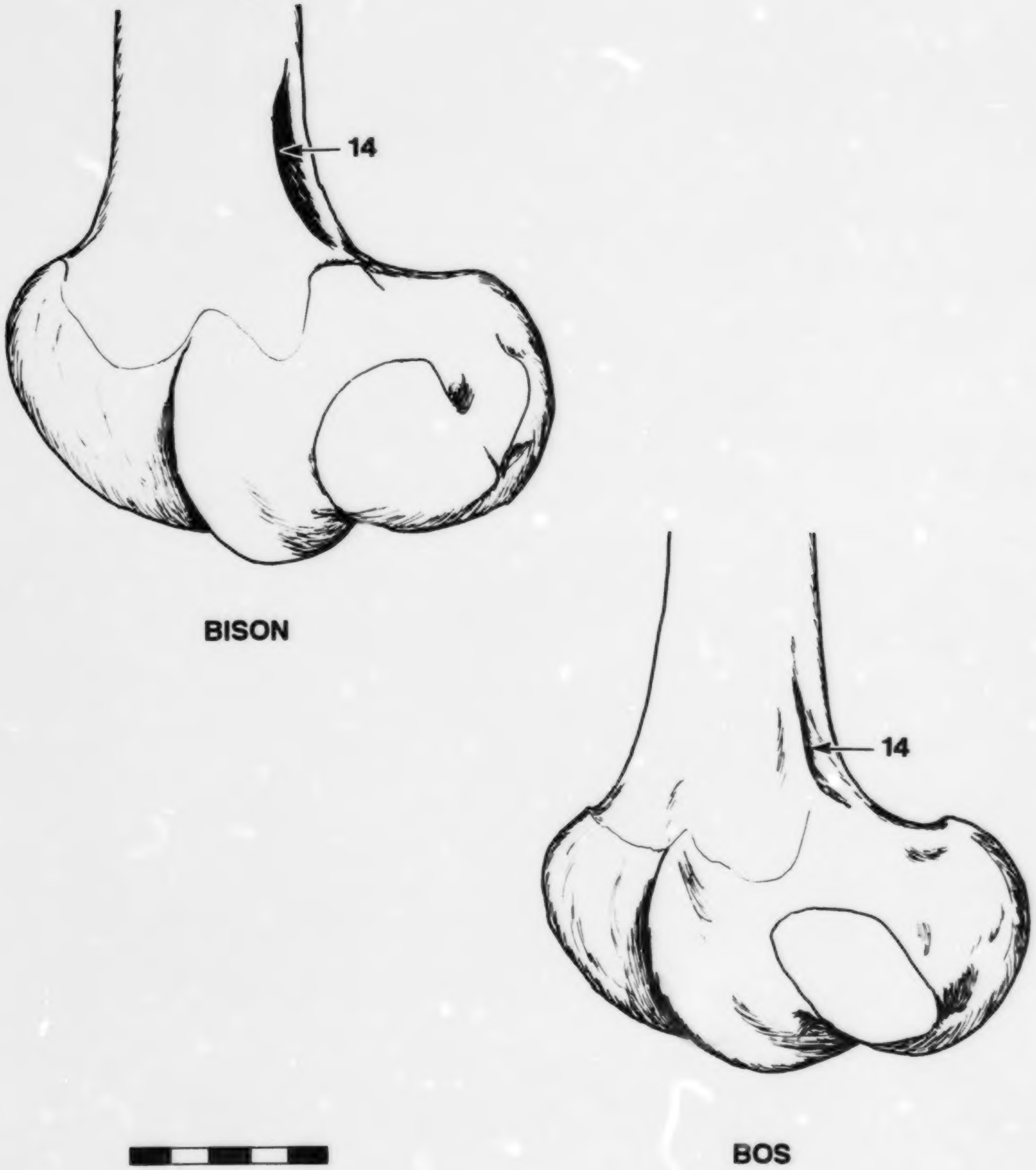
success rate for *Bison*	27/28 = 96.43%
success rate for *Bos*	11/15 = 73.33%

Character #14: supracondyloid fossa	Aspect 1	Aspect 2	Aspect 3
	deeper	shallower	intermediate
No. of *Bison*	27/28	1/28	0/28
No. of *Bos*	2/15	11/15	2/15
Preference Factor *Bison*	6.02	0.07	0.08
Preference Factor *Bos*	0.17	14.37	12.41

(15) The lateral patellar ridge in *Bison* extends further distally relative to the medial ridge than it does in *Bos*. This enables a *Bison* femur to balance vertically on the distal end, while a *Bos* femur will not. (Not illustrated)

success rate for *Bison*	25/27 = 92.59%
success rate for *Bos*	10/15 = 66.67%

Character #15: balances on distal end	Aspect 1	Aspect 2	Aspect 3
	yes	no	intermediate
No. of *Bison*	25/27	2/27	0/27
No. of *Bos*	5/15	10/15	0/15
Preference Factor *Bison*	2.62	0.13	0.56
Preference Factor *Bos*	0.38	7.50	1.77



BISON

BOS

Figure 73. Distal Femur, Lateral View

PATELLA

Fig. 74. Dorsal View

(1) Both species have a serpentine shape, but *Bison* forms an elongated 'S', *Bos* a short stubby 'S'.

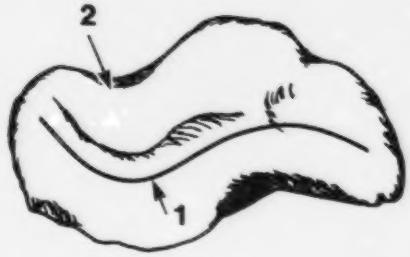
success rate for *Bison*	22/22 = 100.0%
success rate for *Bos*	12/13 = 92.31%

Character #1: serpentine shape	Aspect 1	Aspect 2	Aspect 3
	elongated	short, stubby	intermediate
No. of *Bison*	22/22	0/22	0/22
No. of *Bos*	1/13	12/13	0/13
Preference Factor *Bison*	9.17	0.02	0.60
Preference Factor *Bos*	0.11	56.62	1.67

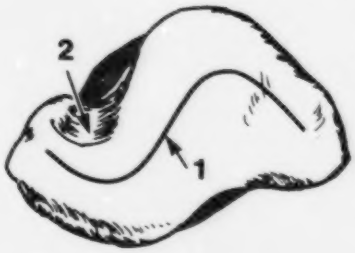
(2) The lateral portion of the anterior margin in *Bos* has a short scooped-out portion. In *Bison* the corresponding area is longer and shallower.

success rate for *Bison*	17/22 = 77.27%
success rate for *Bos*	10/13 = 76.92%

Character #2: scooped-out portion	Aspect 1	Aspect 2	Aspect 3
	long, shallow	short	intermediate
No. of *Bison*	17/22	2/22	3/22
No. of *Bos*	3/13	10/13	0/13
Preference Factor *Bison*	3.01	0.14	5.69
Preference Factor *Bos*	0.33	7.05	0.18



BISON



BOS

Figure 74. Patella, Dorsal View

PATELLA

Fig. 75. Posterior View

(3) On the posterior articular surface, the postero-medial margin forms almost a right angle in *Bison*, but is more obtuse and rounded in *Bos*.

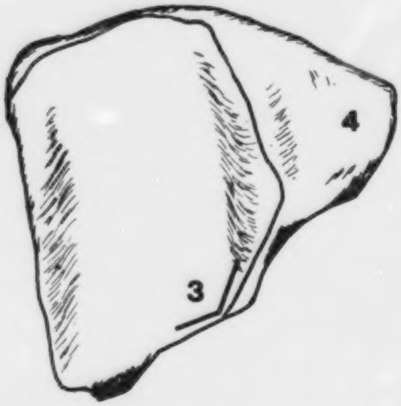
success rate for *Bison*	10/22 = 45.45%
success rate for *Bos*	12/13 = 92.31%

Character #3: postero-medial margin	Aspect 1	Aspect 2	Aspect 3
	right angle	more obtuse	intermediate
No. of *Bison*	10/22	12/22	0/22
No. of *Bos*	1/13	12/13	0/13
Preference Factor *Bison*	4.28	0.60	0.60
Preference Factor *Bos*	0.23	1.67	1.67

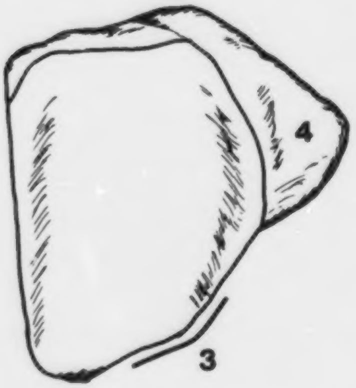
(4) In posterior view, *Bison* features a markedly greater medial projection than does *Bos*.

success rate for *Bison*	21/22 = 95.45%
success rate for *Bos*	12/13 = 92.31%

Character #4: medial projection	Aspect 1	Aspect 2	Aspect 3
	greater	lesser	intermediate
No. of *Bison*	21/22	0/22	1/22
No. of *Bos*	1/13	12/13	0/13
Preference Factor *Bison*	8.76	0.02	2.40
Preference Factor *Bos*	0.11	56.62	0.42



BISON



BOS

Figure 75. Patella, Posterior View

TIBIA

Fig. 76. Posterior View

(1)* In *Bison* the lateral condyle extends farther around on the posterior side of the shaft, ending in a drawn-down point at the postero-lateral corner; in *Bos* this becomes a rounded projection.

success rate for *Bison*	22/27 = 81.48%
success rate for *Bos*	9/14 = 64.29%

Character #1: lateral condyle	Aspect 1	Aspect 2	Aspect 3
	drawn-down	rounded	intermediate
No. of *Bison*	22/27	3/37	2/27
No. of *Bos*	4/14	9/14	1/14
Preference Factor *Bison*	2.64	0.19	0.89
Preference Factor *Bos*	0.38	5.16	1.12

(2)* The first three muscle scars from the lateral border terminate near a common point below the proximal articular surface in *Bos*; the third scar is considerably shorter in *Bison*.

success rate for *Bison*	14/26 = 53.85%
success rate for *Bos*	9/11 = 81.82%

Character #2: third muscle scar	Aspect 1	Aspect 2	Aspect 3
	shorter	even	intermediate
No. of *Bison*	14/26	11/26	1/26
No. of *Bos*	2/11	9/11	0/11
Preference Factor *Bison*	2.53	0.53	1.74
Preference Factor *Bos*	0.39	1.90	0.58

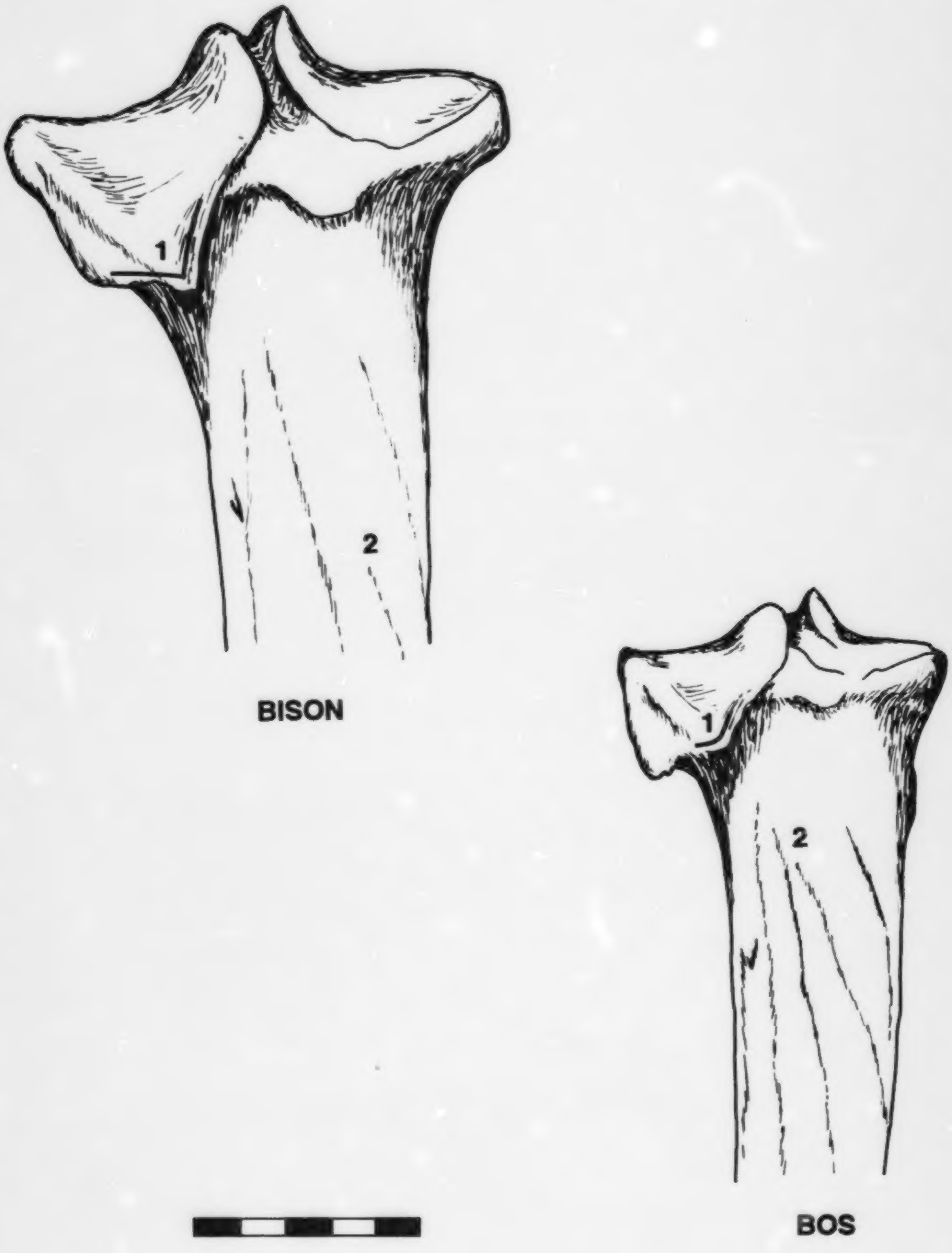

1
2
BISON
1
2
BOS

Figure 76. Proximal Tibia, Posterior View

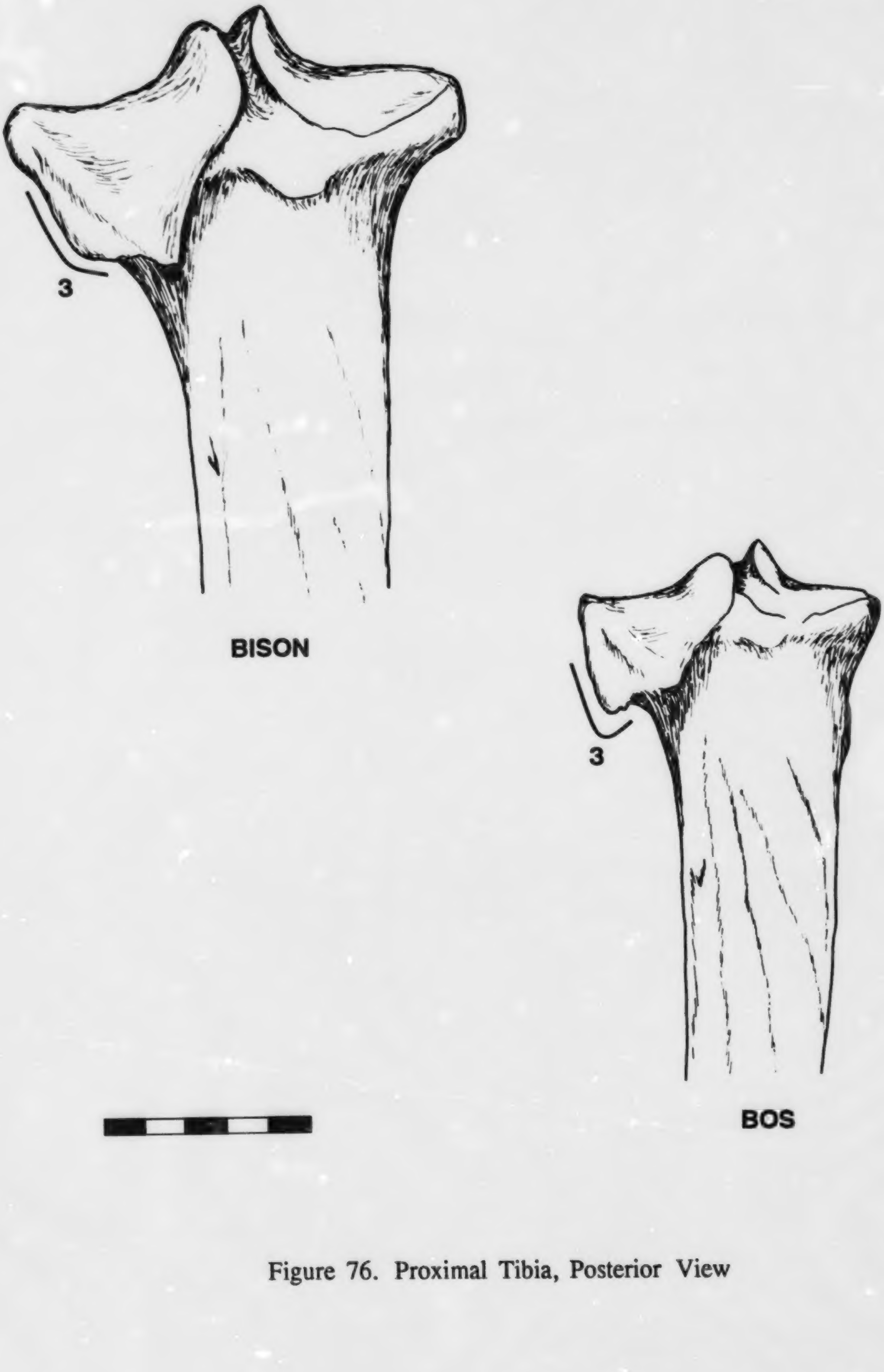
TIBIA

Fig. 76. Posterior View

(3) *Bos* tend to develop a distal projection (the shaft of the fibula) from the lateral condyle.

success rate for *Bison*	26/27 = 96.30%
success rate for *Bos*	13/14 = 92.86%

Character #3: projection from lateral condyle	Aspect 1	Aspect 2	Aspect 3
	absent	present	intermediate
No. of *Bison*	26/27	1/27	0/27
No. of *Bos*	1/14	13/14	0/14
Preference Factor *Bison*	9.49	0.06	0.53
Preference Factor *Bos*	0.11	17.40	1.90



BISON

BOS

Figure 76. Proximal Tibia, Posterior View

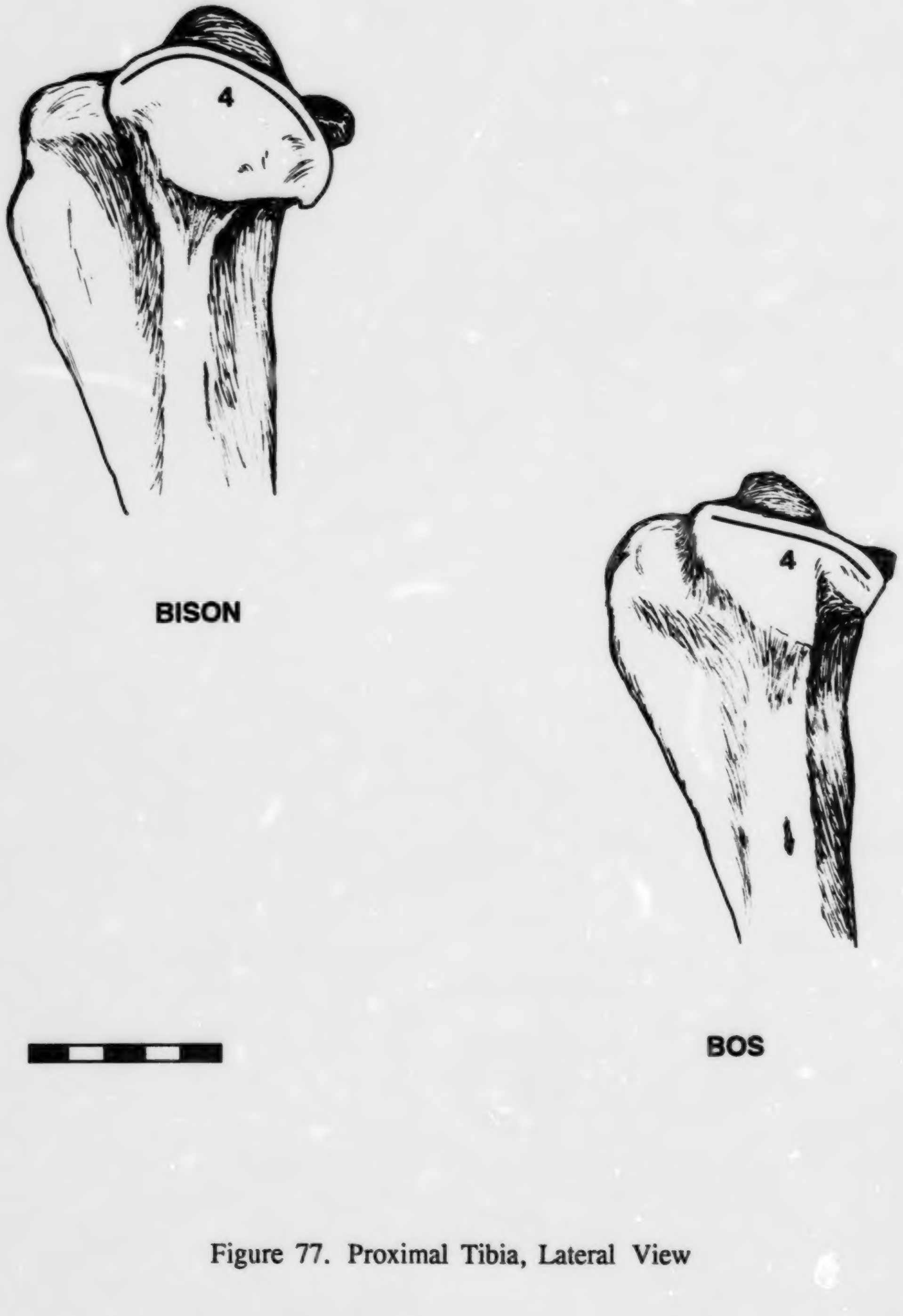
TIBIA

Fig. 77. Lateral View

(4)* The lateral condyle in *Bison* has a continuous curved margin; in *Bos* this surface is nearly straight.

success rate for *Bison*	27/27 = 100.0%
success rate for *Bos*	12/14 = 85.71%

Character #4: lateral condyle margin	Aspect 1	Aspect 2	Aspect 3
	curved	straight	intermediate
No. of *Bison*	27/27	0/27	0/27
No. of *Bos*	2/14	12/14	0/14
Preference Factor *Bison*	5.84	0.02	0.53
Preference Factor *Bos*	0.17	64.43	1.90



BISON

BOS

Figure 77. Proximal Tibia, Lateral View

TIBIA

Fig. 78. Proximal Surface

(5) The posterior margins of the lateral and medial condyles are pointed in *Bos*, rounded in *Bison*. NOTE: This character was noted late in our study and was tested on only 7 *Bison* and 4 *Bos*, so the sample sizes are extremely small.

success rate for *Bison*	7/7 = 100.0%
success rate for *Bos*	4/4 = 100.0%

Character #5: posterior margins of condyles	Aspect 1	Aspect 2	Aspect 3
	rounded	pointed	intermediate
No. of *Bison*	7/7	0/7	0/7
No. of *Bos*	0/4	4/4	0/4
Preference Factor *Bison*	12.21	0.05	0.60
Preference Factor *Bos*	0.08	20.37	1.67

(6) When viewed dorsally the anterior margin of the lateral condyle in *Bison* is slightly curved and meets the lateral margin of this same condyle almost at a right angle. In *Bos* the anterior margin is straighter and the junction with the lateral margin is a more obtuse and rounded angle.

success rate for *Bison*	22/27 = 81.48%
success rate for *Bos*	10/14 = 71.43%

Character #6: margins of lateral condyle	Aspect 1	Aspect 2	Aspect 3
	right angle	obtuse angle	intermediate
No. of *Bison*	22/27	5/27	0/27
No. of *Bos*	3/14	10/14	1/14
Preference Factor *Bison*	3.40	0.28	0.13
Preference Factor *Bos*	0.29	3.63	7.59

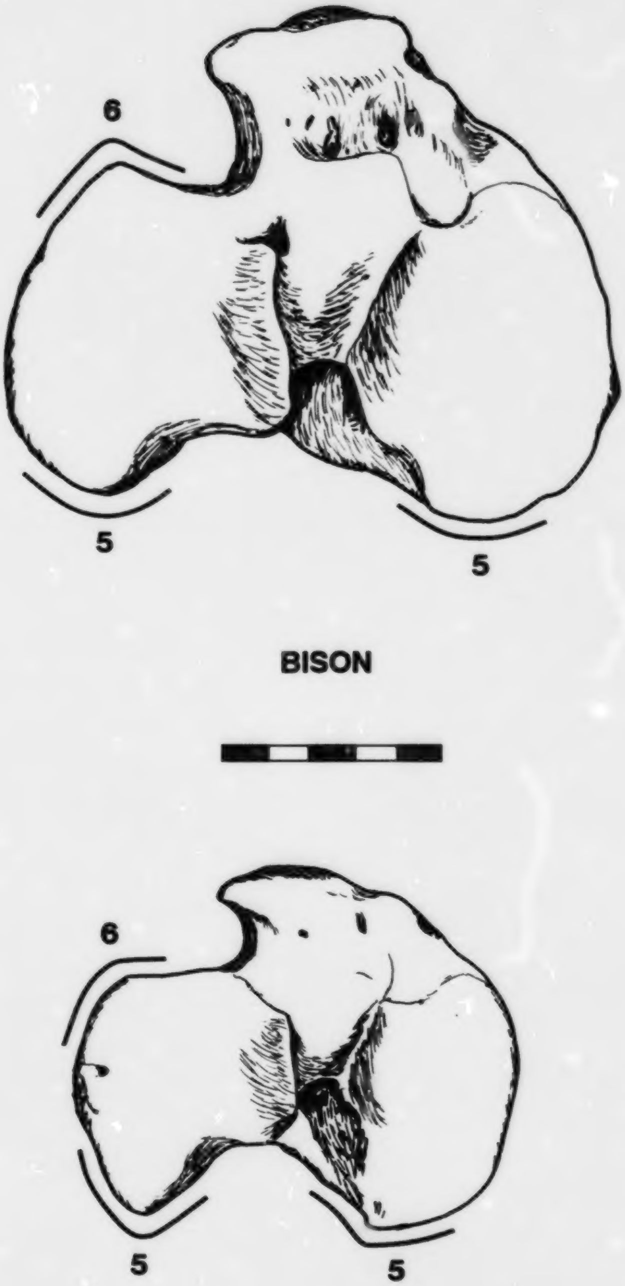

6
5
5
BISON
6
5
5
BOS

Figure 78. Proximal Surface of Tibia

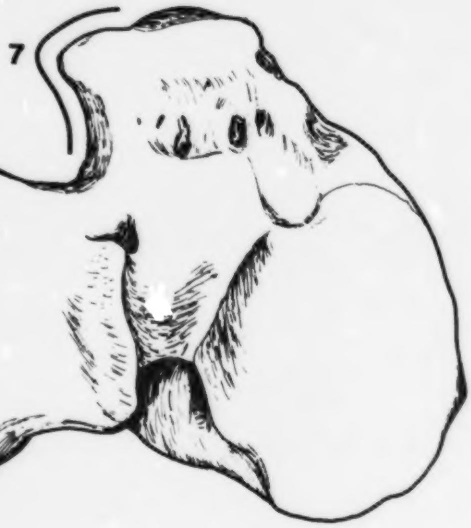
TIBIA

Fig. 78. Proximal Surface

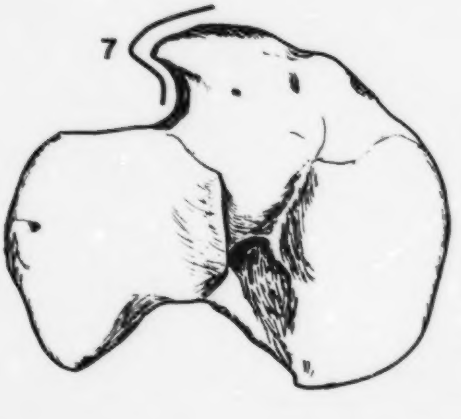
(7) The tibial tuberosity hooks toward the lateral side more in *Bos* than in *Bison*.

success rate for *Bison*	14/26 = 53.85%
success rate for *Bos*	12/13 = 92.31%

Character #7: hooking of tibial tuberosity	Aspect 1 less	Aspect 2 more	Aspect 3 intermediate
No. of *Bison*	14/26	7/26	5/26
No. of *Bos*	0/13	12/13	1/13
Preference Factor *Bison*	20.07	0.31	1.90
Preference Factor *Bos*	0.05	3.27	0.53



BISON



BOS

Figure 78. Proximal Surface of Tibia

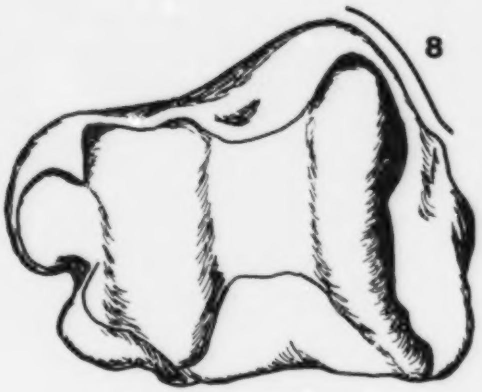
TIBIA

Fig. 79. Ventral View

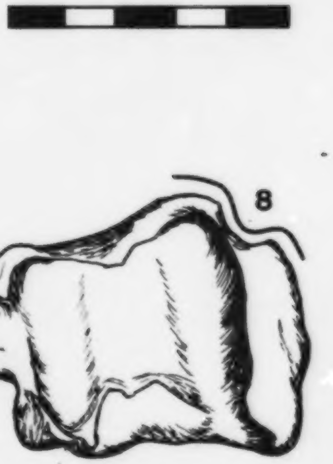
(8)* The groove for the flexor digitalis longus is well developed in *Bos*, but absent or reduced in *Bison*.

success rate for *Bison*	22/28 = 78.57%
success rate for *Bos*	14/15 = 93.33%

Character #8: groove for flexor digitalis longus	Aspect 1	Aspect 2	Aspect 3
	reduced	well-developed	intermediate
No. of *Bison*	22/28	5/28	1/28
No. of *Bos*	0/15	14/15	1/15
Preference Factor *Bison*	33.26	0.21	0.54
Preference Factor *Bos*	0.03	4.85	1.84



BISON



BOS

Figure 79. Tibia, Ventral View

LATERAL MALLEOLUS

Fig. 80. Proximal Surface

(1) *Bison* have two prominent ridges on the proximal surface, one extending anteriorly, the other posteriorly, from the conical projection. *Bos* lack any prominent ridges on this surface.

success rate for *Bison*	21/21 = 100.0%
success rate for *Bos*	11/13 = 84.62%

Character #1: prominent ridges	Aspect 1	Aspect 2	Aspect 3
	present	absent	intermediate
No. of *Bison*	21/21	0/21	0/21
No. of *Bos*	0/13	11/13	2/13
Preference Factor *Bison*	36.69	0.02	0.09
Preference Factor *Bos*	0.03	49.78	10.75

(2) The proximal articular surface in *Bison* has a scooped-out area antero-medial to the conical projection. In *Bos* the anterior portion of the proximal articular surface is flat or only slightly depressed.

success rate for *Bison*	19/20 = 95.00%
success rate for *Bos*	11/12 = 91.67%

Character #2: antero-medial area	Aspect 1	Aspect 2	Aspect 3
	scooped-out	flatter	intermediate
No. of *Bison*	19/20	1/20	0/20
No. of *Bos*	1/12	11/12	0/12
Preference Factor *Bison*	8.08	0.08	0.61
Preference Factor *Bos*	0.12	12.81	1.64

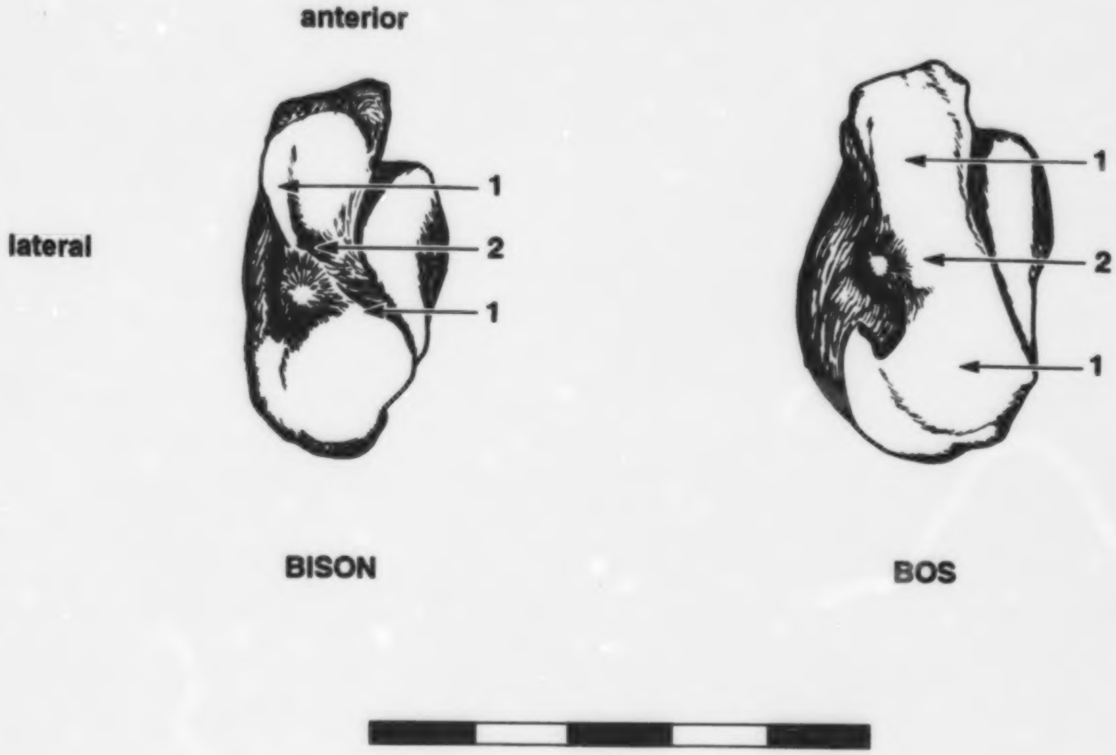

anterior
lateral
1
2
1
1
2
1
BISON
BOS

Figure 80. Lateral Malleolus, Proximal Surface

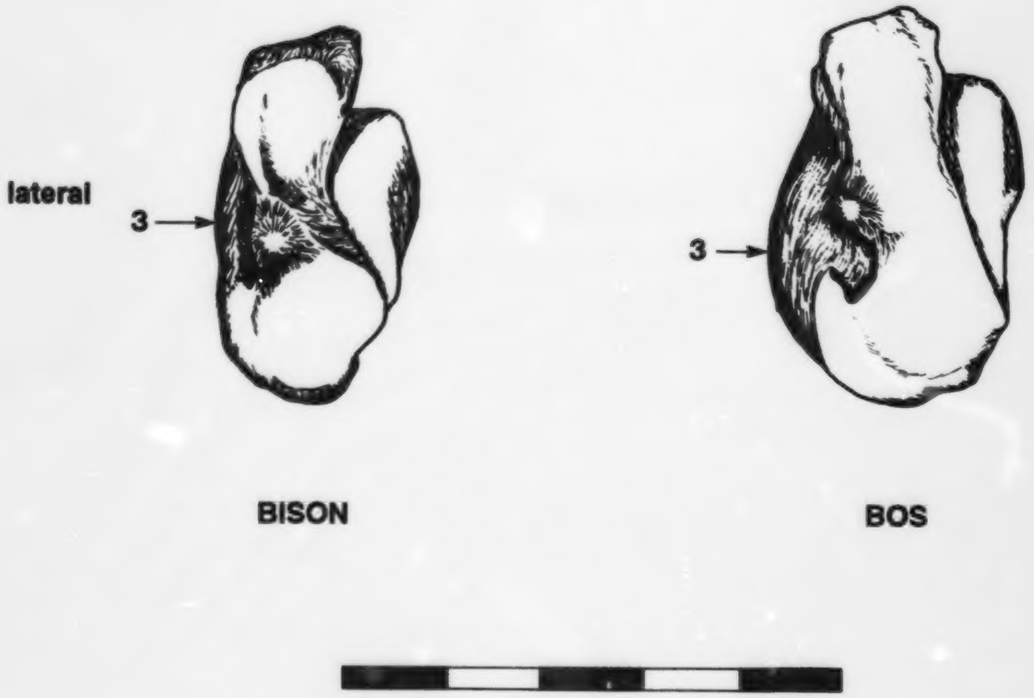
LATERAL MALLEOLUS

Fig. 80. Proximal Surface

(3) The lateral margin is strongly protuberant in *Bos*, gently rounded in *Bison*.

success rate for *Bison*	20/20 = 100.0%
success rate for *Bos*	12/12 = 100.0%

Character #3: lateral margin	Aspect 1	Aspect 2	Aspect 3
	gently rounded	strongly protuberant	intermediate
No. of *Bison*	20/20	0/20	0/20
No. of *Bos*	0/12	12/12	0/12
Preference Factor *Bison*	33.97	0.02	0.61
Preference Factor *Bos*	0.03	55.72	1.64



BISON

BOS

Figure 80. Lateral Malleolus, Proximal Surface

LATERAL MALLEOLUS

Fig. 81. Lateral View

(4) The anterior portion of the lateral surface is "dished-out" in *Bos* but not in *Bison*.

success rate for *Bison*	22/23 = 95.65%
success rate for *Bos*	10/13 = 76.92%

Character #4: dished-out area	Aspect 1	Aspect 2	Aspect 3
	absent	present	intermediate
No. of *Bison*	22/23	0/23	1/23
No. of *Bos*	1/13	10/13	2/13
Preference Factor *Bison*	8.78	0.02	0.34
Preference Factor *Bos*	0.11	49.67	2.94

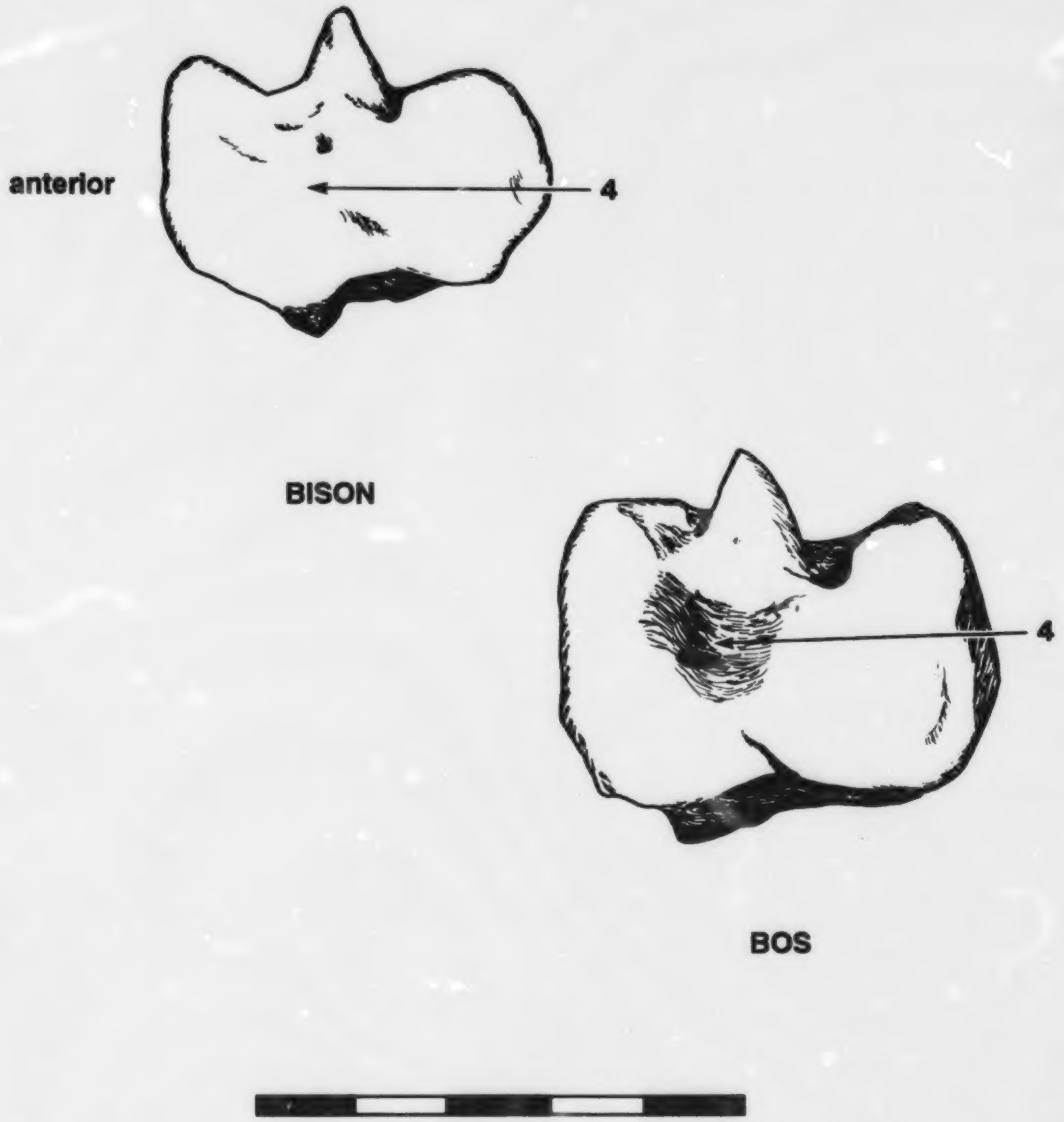

anterior
4
BISON
4
BOS

Figure 81. Lateral Malleolus, Lateral View

LATERAL MALLEOLUS

Fig. 82. Medial View

(5) The anterior margin in *Bison* tapers posteriorly, whereas in *Bos* it is straighter.

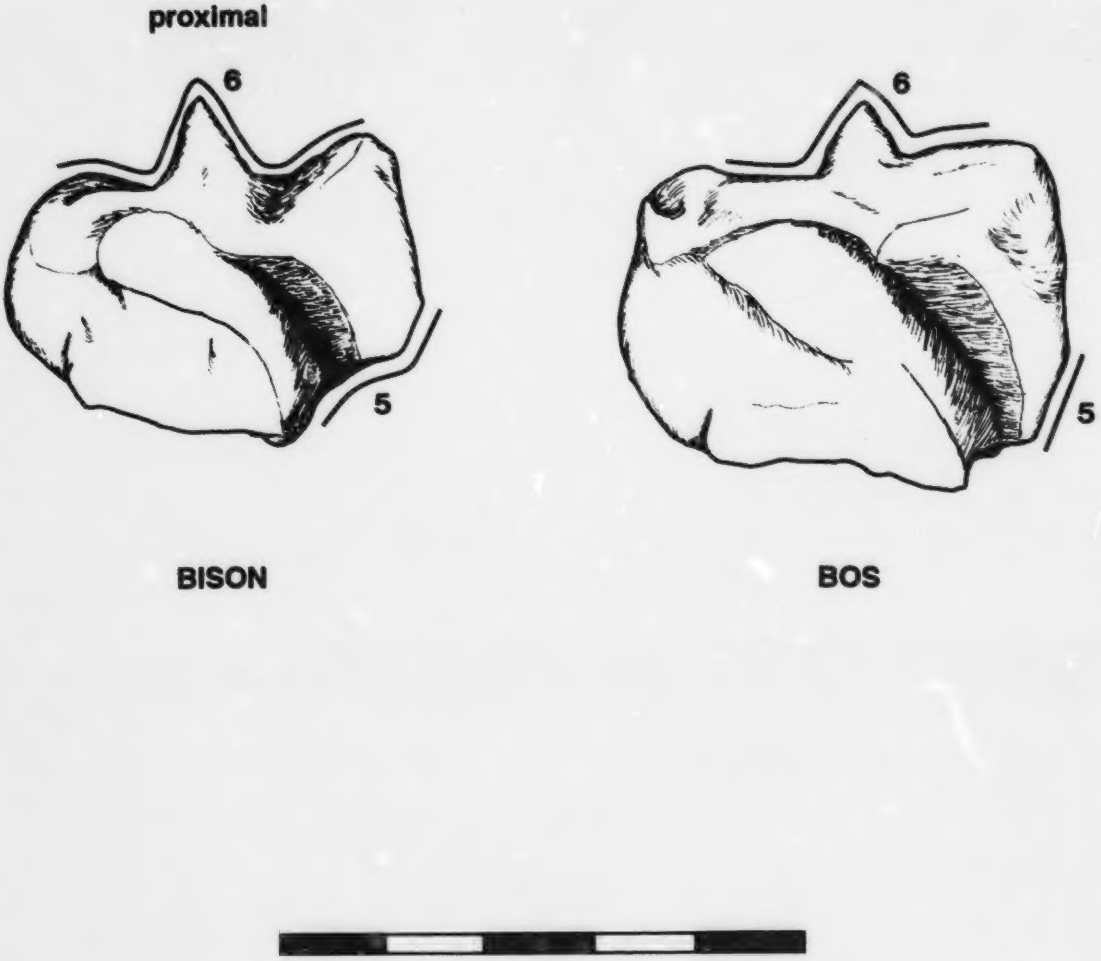
success rate for *Bison*	8/23 = 34.78%
success rate for *Bos*	13/13 = 100.0%

Character #5: anterior margin	Aspect 1	Aspect 2	Aspect 3
	tapers	straighter	intermediate
No. of *Bison*	8/23	14/23	1/23
No. of *Bos*	0/13	13/13	0/13
Preference Factor *Bison*	13.26	0.62	2.30
Preference Factor *Bos*	0.08	1.62	0.44

(6) In *Bison*, the conical proximal projection is large and rises abruptly, almost at right angles to the proximal margin. In *Bos*, this projection is much smaller and it forms an obtuse angle with the proximal margin.

success rate for *Bison*	17/22 = 77.27%
success rate for *Bos*	11/12 = 91.67%

Character #6: conical proximal projection	Aspect 1	Aspect 2	Aspect 3
	large	small	intermediate
No. of *Bison*	17/22	4/22	1/22
No. of *Bos*	1/12	11/12	0/12
Preference Factor *Bison*	6.60	0.22	2.22
Preference Factor *Bos*	0.15	4.61	0.44


proximal
6
5
6
5

BISON

BOS

Figure 82. Lateral Malleolus, Medial View

FIBULAR TARSAL (CALCANEUM)

Fig. 83. Medial View

(1) The face of the sustentaculum is scooped-out in *Bison*, more flattened in *Bos*.

success rate for *Bison*	25/26 = 96.15%
success rate for *Bos*	13/15 = 86.67%

Character #1: face of sustentaculum	Aspect 1	Aspect 2	Aspect 3
	scooped-out	flatter	intermediate
No. of *Bison*	25/26	1/26	0/26
No. of *Bos*	2/15	13/15	0/15
Preference Factor *Bison*	6.01	0.06	0.58
Preference Factor *Bos*	0.17	15.68	1.71

(2)* The margin of the sustentaculum forms almost a right angle in *Bos*. In *Bison* it is more rounded, forming a continuous curve.

success rate for *Bison*	24/26 = 92.31%
success rate for *Bos*	14/15 = 93.33%

Character #2: margin of sustentaculum	Aspect 1	Aspect 2	Aspect 3
	rounded	right angled	intermediate
No. of *Bison*	24/26	0/26	2/26
No. of *Bos*	0/15	14/15	1/15
Preference Factor *Bison*	38.95	0.01	0.99
Preference Factor *Bos*	0.05	67.38	1.01

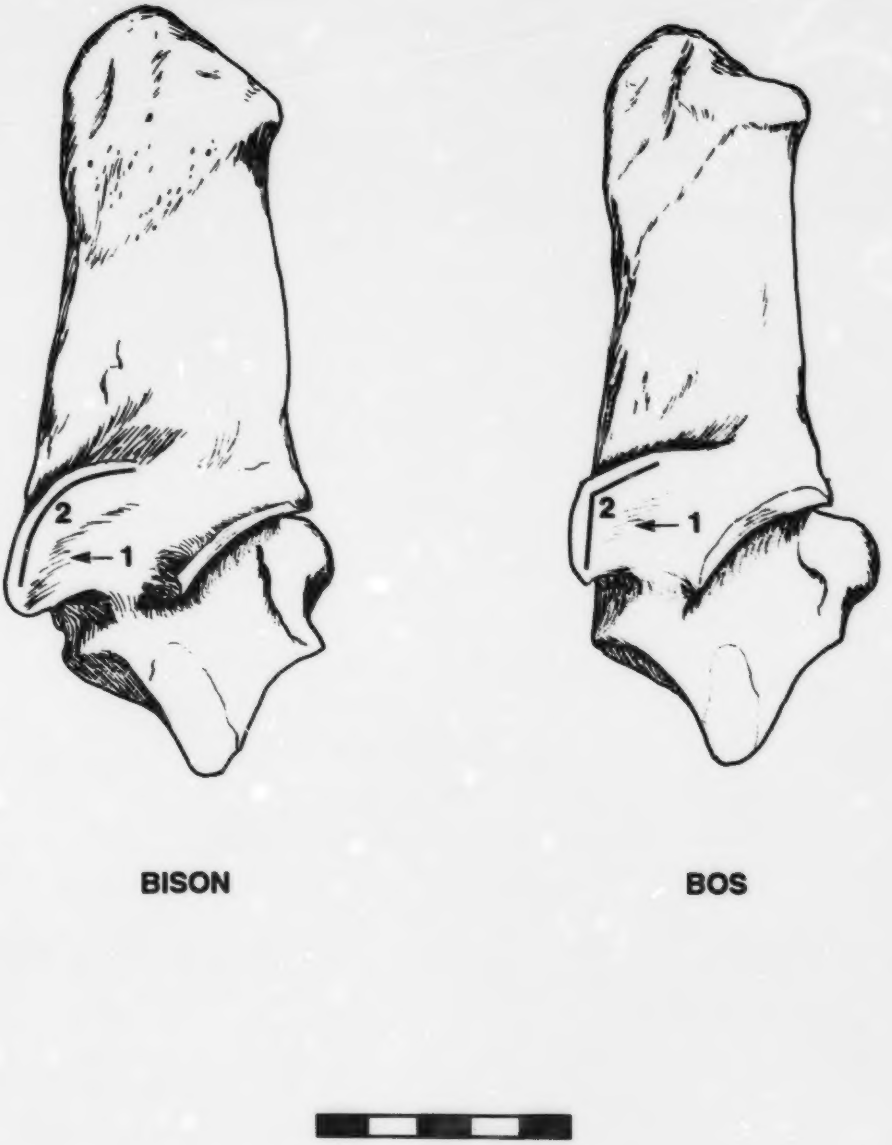

2
1
2
1
BISON
BOS

Figure 83. Fibular Tarsal (Calcaneum), Medial View

FIBULAR TARSAL (CALCANEUM)

Fig. 84. Posterior View

(3)* The sustentaculum is angled downwards in *Bison*, whereas in *Bos* it projects almost perpendicularly.

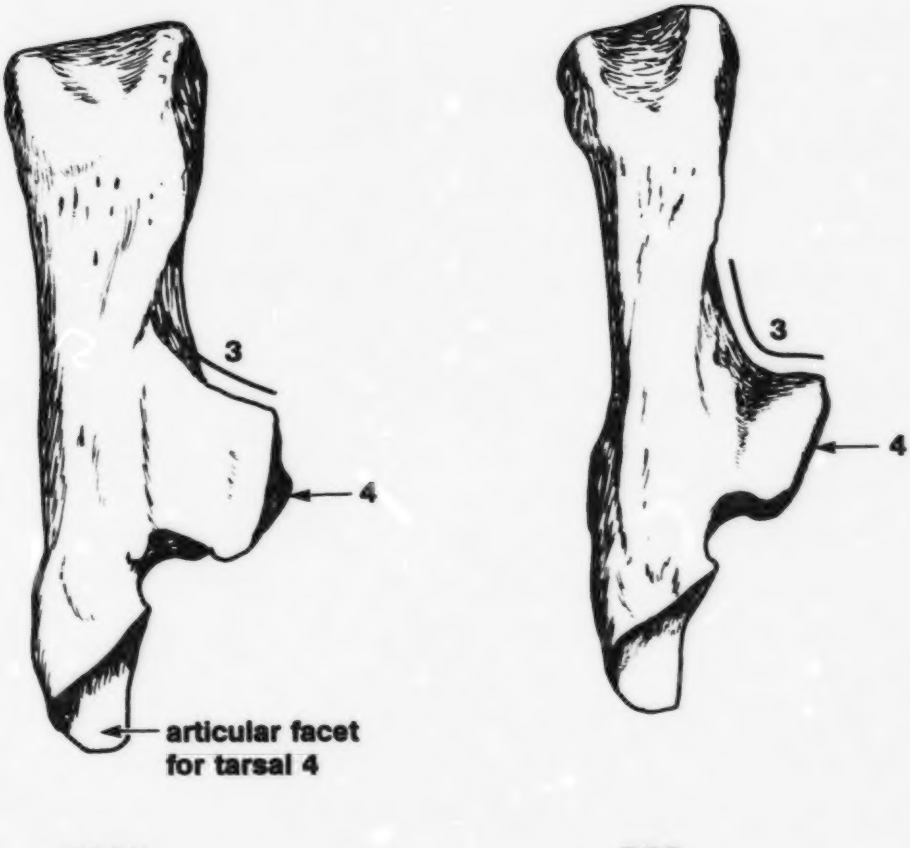
success rate for *Bison*	15/26 = 57.69%
success rate for *Bos*	11/15 = 73.33%

Character #3: projection of sustentaculum	Aspect 1	Aspect 2	Aspect 3
	downwards	perpendicular	intermediate
No. of *Bison*	15/26	11/26	0/26
No. of *Bos*	4/15	11/15	0/15
Preference Factor *Bison*	2.02	0.58	0.58
Preference Factor *Bos*	0.50	1.71	1.71

(4) A medial-ventral extension of the sustentaculum is visible in *Bison*, but much less noticeable in *Bos*. NOTE: To observe this distinction, the calcaneum must be oriented exactly as in Figure 84, so that all of the articular facet for tarsal 4 is visible.

success rate for *Bison*	13/24 = 54.17%
success rate for *Bos*	14/14 = 100.0%

Character #4: medial-ventral extension	Aspect 1	Aspect 2	Aspect 3
	visible	not noticeable	intermediate
No. of *Bison*	13/24	9/24	2/24
No. of *Bos*	0/14	14/14	0/14
Preference Factor *Bison*	21.71	0.39	3.99
Preference Factor *Bos*	0.05	2.58	0.25


3
4
articular facet for tarsal 4
3
4

BISON

BOS

Figure 84. Fibular Tarsal (Calcaneum), Posterior View

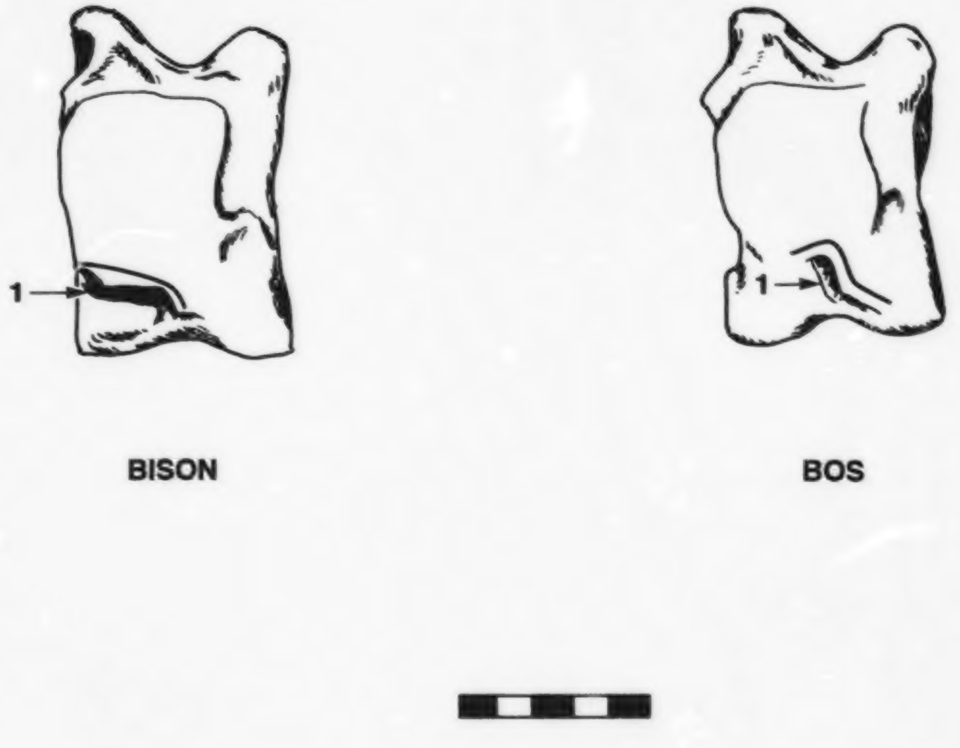
TIBIAL TARSAL (ASTRAGALUS)

Fig. 85. Posterior View

(1) In *Bison* the excavated area on the posterior surface is perpendicular to, and extends as far as, the lateral margin. In *Bos*, this excavation does not extend as far as the lateral margin.

success rate for *Bison*	23/26 = 88.46%
success rate for *Bos*	12/15 = 80.00%

Character #1: excavated area on posterior surface	Aspect 1	Aspect 2	Aspect 3
	extends to lateral margin	does not reach lateral margin	intermediate
No. of *Bison*	23/26	2/26	1/26
No. of *Bos*	2/15	12/15	1/15
Preference Factor *Bison*	5.53	0.12	0.58
Preference Factor *Bos*	0.18	8.60	1.71



BISON **BOS**

Figure 85. Tibial Tarsal (Astragalus), Posterior View

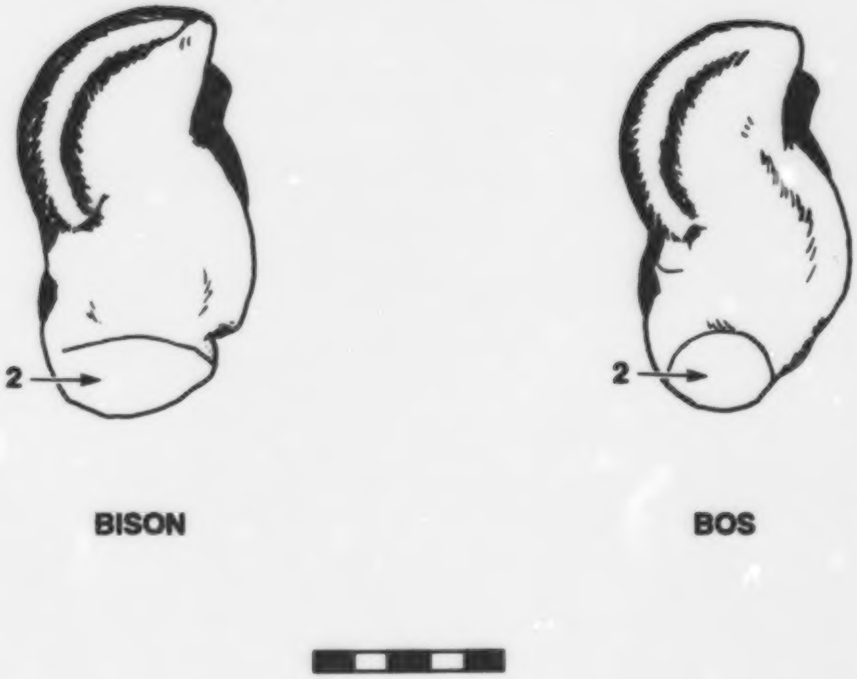
TIBIAL TARSAL (ASTRAGALUS)

Fig. 86. Lateral View

(2) The lateral articular surface of the distal trochlea seems to cover the distal surface completely in *Bison*. In *Bos*, this surface is smaller, rounded and pad-like.

success rate for *Bison*	22/25 = 88.00%
success rate for *Bos*	7/14 = 50.00%

Character #2: lateral articular surface	Aspect 1	Aspect 2	Aspect 3
	covers distal surface	smaller, rounded	intermediate
No. of *Bison*	22/25	2/25	1/25
No. of *Bos*	7/14	7/14	0/14
Preference Factor *Bison*	1.71	0.19	2.27
Preference Factor *Bos*	0.59	5.31	0.44



BISON

BOS

Figure 86. Tibial Tarsal (Astragalus), Lateral View

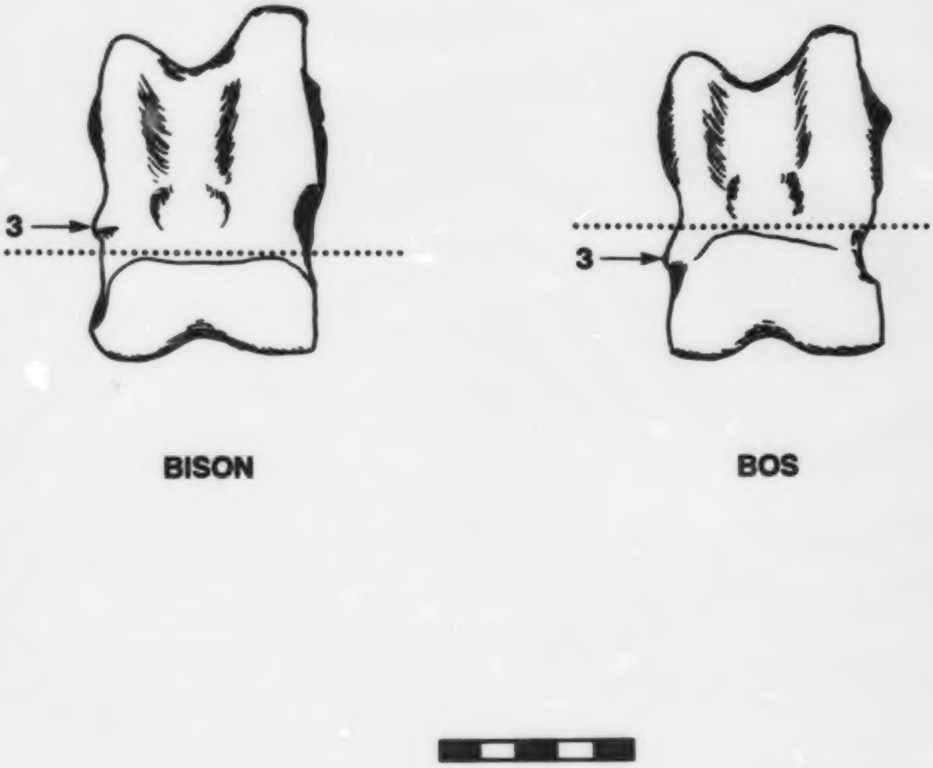
TIBIAL TARSAL (ASTRAGALUS)

Fig. 87. Anterior View

(3)* The medial tubercle in *Bos* is well below a line drawn across the proximal margins of the distal trochlea. In *Bison*, the tubercle is on a level with or above the same line.

success rate for *Bison*	27/27 = 100.0%
success rate for *Bos*	10/15 = 66.67%

Character #3: medial tubercle	Aspect 1	Aspect 2	Aspect 3
	above line	below line	intermediate
No. of *Bison*	27/27	0/27	0/27
No. of *Bos*	4/15	10/15	1/15
Preference Factor *Bison*	3.45	0.02	0.14
Preference Factor *Bos*	0.29	50.63	7.10



BISON

BOS

Figure 87. Tibial Tarsal (Astragalus), Anterior View

TIBIAL TARSAL (ASTRAGALUS)

Fig. 88. Medial View

(4) In *Bison*, the medial tubercle extends antero-medially from a noticeable break in the curve of the medial half of the proximal trochlea. In *Bos*, this tubercle is flattened or extends as an unbroken curve.

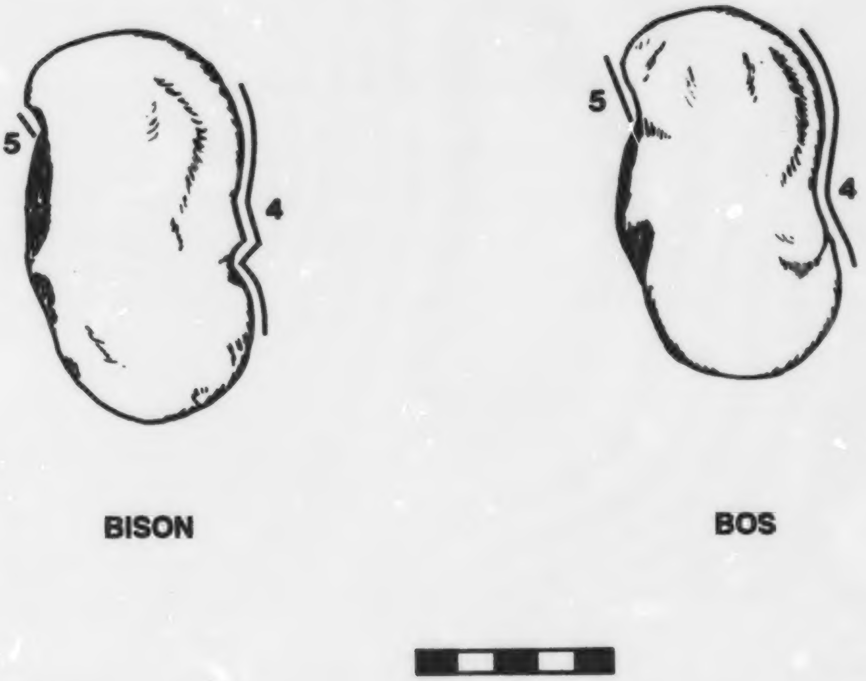
success rate for *Bison*	26/27 = 96.30%
success rate for *Bos*	13/15 = 86.67%

Character #4: medial tubercle	Aspect 1	Aspect 2	Aspect 3
	extends	flattened	intermediate
No. of *Bison*	26/27	0/27	1/27
No. of *Bos*	2/15	13/15	0/15
Preference Factor *Bison*	6.01	0.02	2.25
Preference Factor *Bos*	0.17	65.10	0.44

(5) In *Bos* the proximo-plantar corner of the trochlea is separated from the plantar articular surface by a well-defined "neck". This neck is absent or very reduced in *Bison*.

success rate for *Bison*	22/26 = 84.62%
success rate for *Bos*	9/13 = 69.23%

Character #5: well-defined "neck"	Aspect 1	Aspect 2	Aspect 3
	absent	present	intermediate
No. of *Bison*	22/26	3/26	1/26
No. of *Bos*	4/13	9/13	0/13
Preference Factor *Bison*	2.55	0.19	2.04
Preference Factor *Bos*	0.39	5.34	0.49



BISON

BOS

Figure 88. Tibial Tarsal (Astragalus), Medial View

CENTRAL + 4TH TARSAL

Fig. 89. Distal Surface

(1)* In *Bison* there is a continuous surface connecting the distal articular surface for the first tarsal and that of the fused second and third tarsals. In *Bos* there is a separation between these articular surfaces.

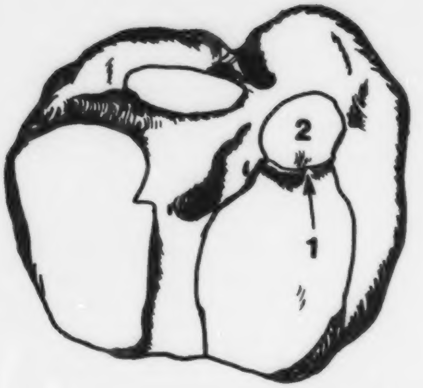
success rate for *Bison*	19/23 = 82.61%
success rate for *Bos*	5/12 = 41.67%

Character #1: articular surfaces	Aspect 1	Aspect 2	Aspect 3
	continuous	separate	intermediate
No. of *Bison*	19/23	2/23	2/23
No. of *Bos*	7/12	5/12	0/12
Preference Factor *Bison*	1.38	0.24	3.59
Preference Factor *Bos*	0.72	4.16	0.28

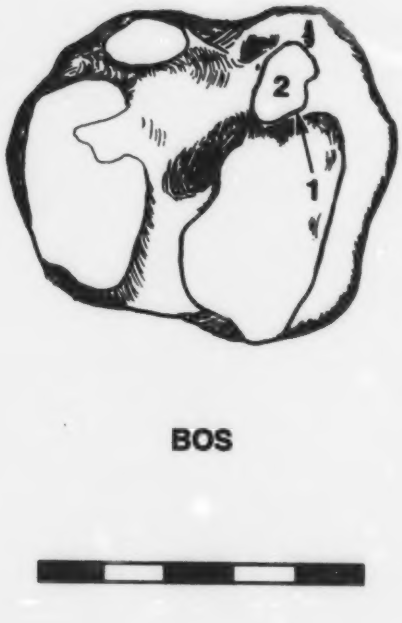
(2) The articular surface for the first tarsal in *Bos* is elongated in an antero-posterior direction; in *Bison* it is more rounded.

success rate for *Bison*	18/23 = 78.26%
success rate for *Bos*	11/13 = 84.62%

Character #2: articular surface for first tarsal	Aspect 1	Aspect 2	Aspect 3
	rounded	elongated	intermediate
No. of *Bison*	18/23	4/23	1/23
No. of *Bos*	2/13	11/13	0/13
Preference Factor *Bison*	4.28	0.22	2.30
Preference Factor *Bos*	0.23	4.46	0.44



BISON



BOS

Figure 89. Central + 4th Tarsal, Distal Surface

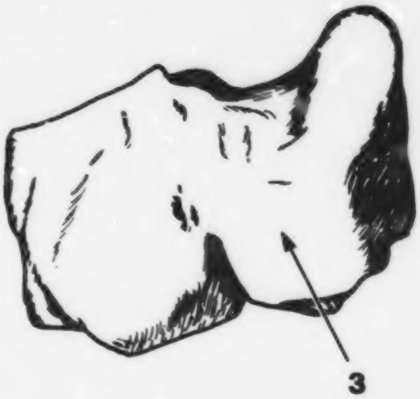
CENTRAL + 4TH TARSAL

Fig. 90. Posterior View

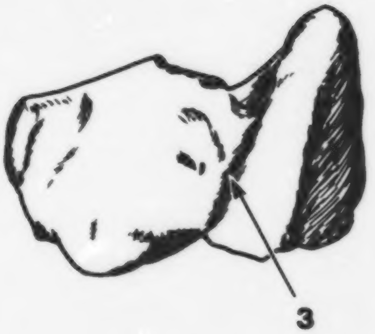
(3) The ventro-medial portion of the posterior surface is scooped out in *Bos*, so that the medial edge stands out in a prominent narrow ridge. In *Bison* this area is not as trough-like and the ridge is consequently poorly defined.

success rate for *Bison*	14/22 = 63.64%
success rate for *Bos*	13/13 = 100.0%

Character #3: medial edge ridge	Aspect 1	Aspect 2	Aspect 3
	poorly defined	prominent	intermediate
No. of *Bison*	14/22	5/22	3/22
No. of *Bos*	0/13	13/13	0/13
Preference Factor *Bison*	23.64	0.24	5.69
Preference Factor *Bos*	0.04	4.10	0.18



BISON



BOS

Figure 90. Central + 4th Tarsal, Posterior View

TARSAL 2+3

Fig. 91. Ventral View

(1) The posterior margin of the ventral articular surface is straight or very slightly curved in *Bison*, strongly curved in *Bos*.

success rate for *Bison*	12/21 = 57.14%
success rate for *Bos*	12/13 = 92.31%

Character #1: posterior margin, ventral view	Aspect 1	Aspect 2	Aspect 3
	straight	strongly curved	intermediate
No. of *Bison*	12/21	4/21	5/21
No. of *Bos*	1/13	12/13	0/13
Preference Factor *Bison*	5.33	0.23	9.37
Preference Factor *Bos*	0.19	4.43	0.11

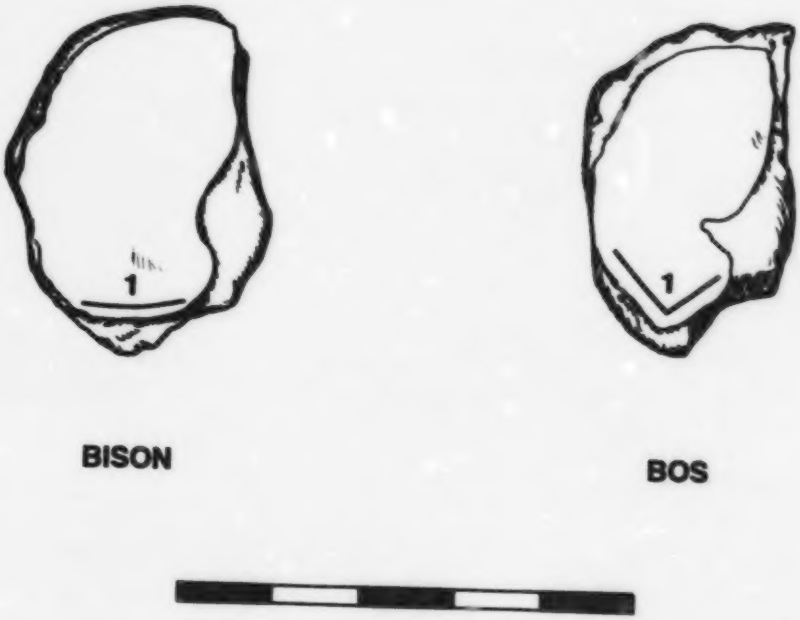

1
1
BISON
BOS

Figure 91. Tarsal 2+3, Ventral View

TARSAL 2+3

Fig. 92. Posterior View

(2) The posterior margin of the ventral articular surface dips sharply downward in *Bison* and is straight across in *Bos*.

success rate for *Bison*	20/21 = 95.24%
success rate for *Bos*	6/13 = 46.15%

Character #2: posterior margin, posterior view	Aspect 1	Aspect 2	Aspect 3
	dips sharply	straight	intermediate
No. of *Bison*	20/21	0/21	1/21
No. of *Bos*	6/13	6/13	1/13
Preference Factor *Bison*	1.98	0.04	0.63
Preference Factor *Bos*	0.50	28.12	1.59

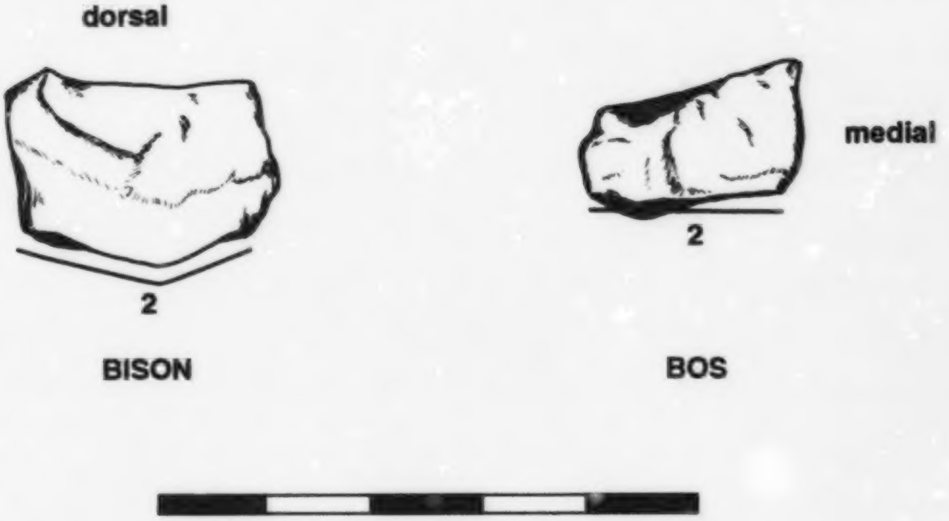

dorsal
medial
2
2
BISON
BOS

Figure 92. Tarsal 2+3, Posterior View

TARSAL 2+3

Fig. 93. Dorsal View

(3) The posterior margin of the dorsal articular surface is strongly curved in *Bos*, so that the postero-medial corner projects more sharply posteriorly. The posterior margin in *Bison* is only slightly curved, so that there is little projection of the postero-medial corner.

success rate for *Bison*	13/22 = 59.09%
success rate for *Bos*	8/11 = 72.73%

Character #3: postero-medial projection	Aspect 1	Aspect 2	Aspect 3
	slight	stronger	intermediate
No. of *Bison*	13/22	6/22	3/22
No. of *Bos*	2/11	8/11	1/11
Preference Factor *Bison*	2.78	0.39	1.21
Preference Factor *Bos*	0.36	2.56	0.83

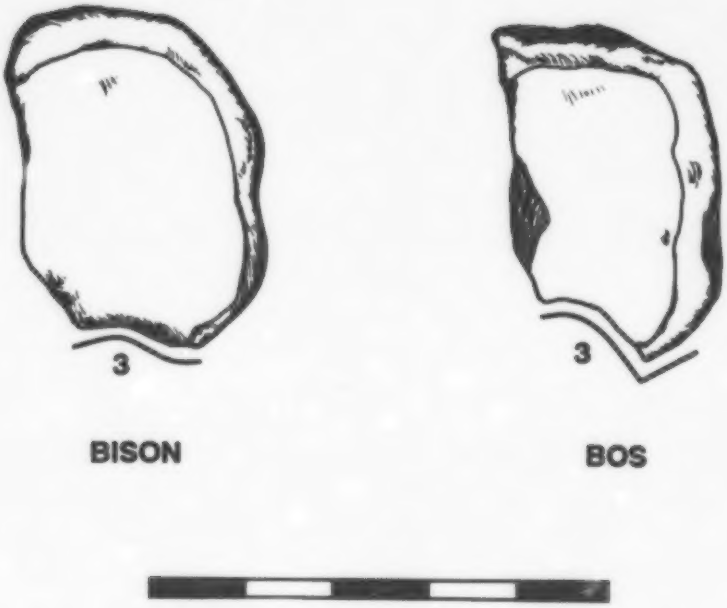

3
3
BISON
BOS

Figure 93. Tarsal 2+3, Dorsal View

METATARSAL 3+4

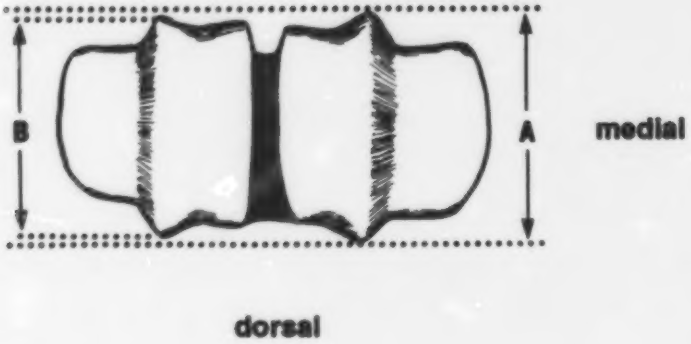
Fig. 94. Ventral View

(1) In *Bison* the dorso-plantar depth of the medial condyle (A in Fig. 94) is measurably greater than that of the lateral condyle (B in Fig. 94). In *Bos* the two condyles are almost the same size, the medial being only slightly larger than the lateral.

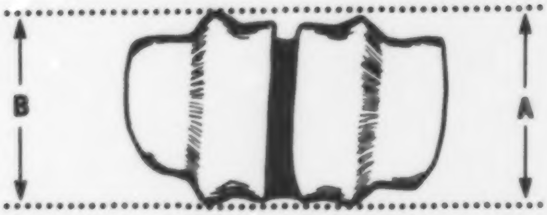
NOTE: It is necessary to use calipers to detect this distinction, as any size difference between the two condyles is not readily apparent to the eye alone. A more detailed discussion of this character, with the results of statistical testing of the sample means of the two species, is given in Appendix 2.

success rate for *Bison*	21/26 = 80.77%
success rate for *Bos*	12/12 = 100.0%

Character #1: medial:lateral condyle ratio	Aspect 1	Aspect 2	Aspect 3
	medial greater	almost same	intermediate
No. of *Bison*	21/26	3/26	2/26
No. of *Bos*	0/12	12/12	0/12
Preference Factor *Bison*	27.56	0.13	3.18
Preference Factor *Bos*	0.04	7.60	0.31


B
A
medial
dorsal

BISON



BOS

Figure 94. Metatarsal 3+4, Ventral View

METATARSAL 3+4

Fig. 95. Dorsal View

(2) The greatest proximal width (GPW) for *Bos* occurs from the antero-medial corner to the postero-lateral corner. In *Bison*, the GPW is from antero-lateral to postero-medial.

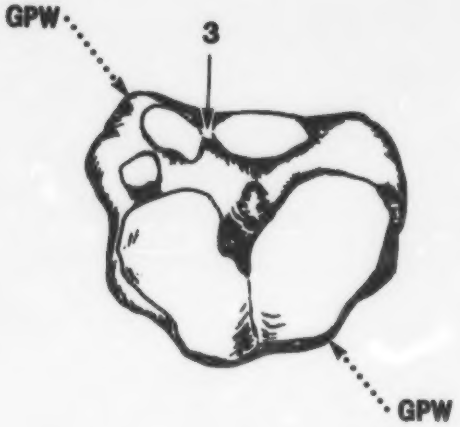
success rate for *Bison*	21/27 = 77.78%
success rate for *Bos*	8/13 = 61.54%

Character #2: greatest proximal width	Aspect 1	Aspect 2	Aspect 3
	antero-lateral to postero-medial	antero-medial to postero-lateral	intermediate
No. of *Bison*	21/27	3/27	3/27
No. of *Bos*	3/13	8/13	2/13
Preference Factor *Bison*	3.03	0.28	0.69
Preference Factor *Bos*	0.33	4.96	1.45

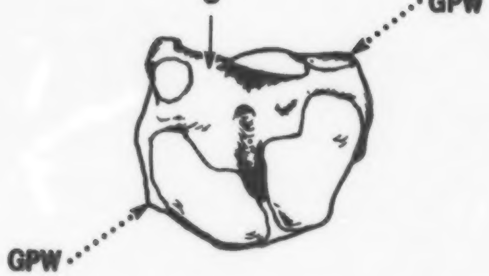
(3)* In *Bison*, a narrow neck or ridge joins the articular surface for the first tarsal to the posterior articular surface for the central and fourth tarsal. No ridge is present in *Bos* and the articular surfaces are separate.

success rate for *Bison*	23/25 = 92.00%
success rate for *Bos*	10/11 = 90.91%

Character #3: articular surfaces	Aspect 1	Aspect 2	Aspect 3
	joined by neck	separate	intermediate
No. of *Bison*	23/25	1/25	1/25
No. of *Bos*	1/11	10/11	0/11
Preference Factor *Bison*	7.20	0.06	1.80
Preference Factor *Bos*	0.14	15.82	0.55



BISON



BOS

Figure 95. Metatarsal 3+4, Dorsal View

METATARSAL 3+4

Fig. 96. Dorsal View

(4) The dorsal groove along the shaft is more obvious in *Bos* than in *Bison*.

success rate for *Bison*	17/24 = 70.83%
success rate for *Bos*	12/12 = 100.0%

Character #4: dorsal groove along shaft	Aspect 1	Aspect 2	Aspect 3
	less obvious	more obvious	intermediate
No. of *Bison*	17/24	3/24	4/24
No. of *Bos*	0/12	12/12	0/12
Preference Factor *Bison*	24.26	0.14	6.23
Preference Factor *Bos*	0.04	7.02	0.16

(5)* *Bison* show a swelling above the distal condyles; *Bos* do not.

success rate for *Bison*	24/27 = 88.89%
success rate for *Bos*	10/14 = 71.43%

Character #5: swelling above distal condyles	Aspect 1	Aspect 2	Aspect 3
	present	absent	intermediate
No. of *Bison*	24/27	2/27	1/27
No. of *Bos*	2/14	10/14	2/14
Preference Factor *Bison*	5.20	0.12	0.31
Preference Factor *Bos*	0.19	8.02	3.20

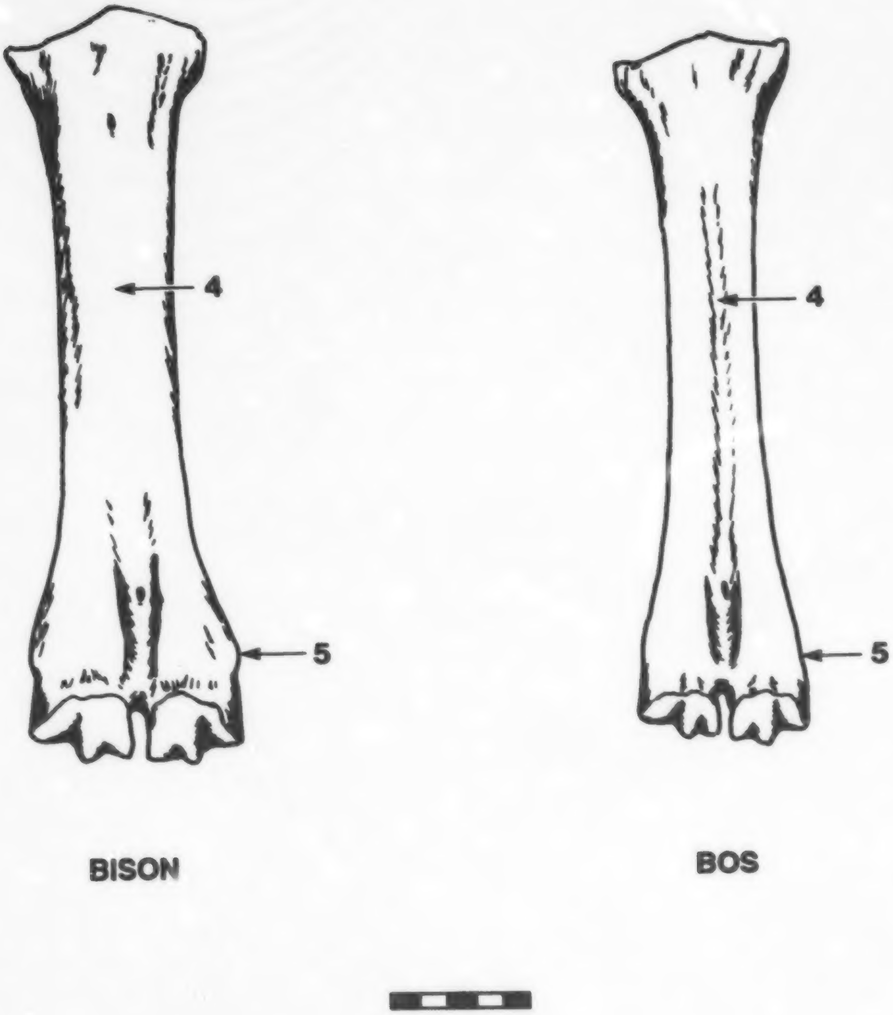

4
5
4
5
BISON
BOS

Figure 96. Metatarsal 3+4, Dorsal View

METATARSAL 3+4

Fig. 96. Dorsal View

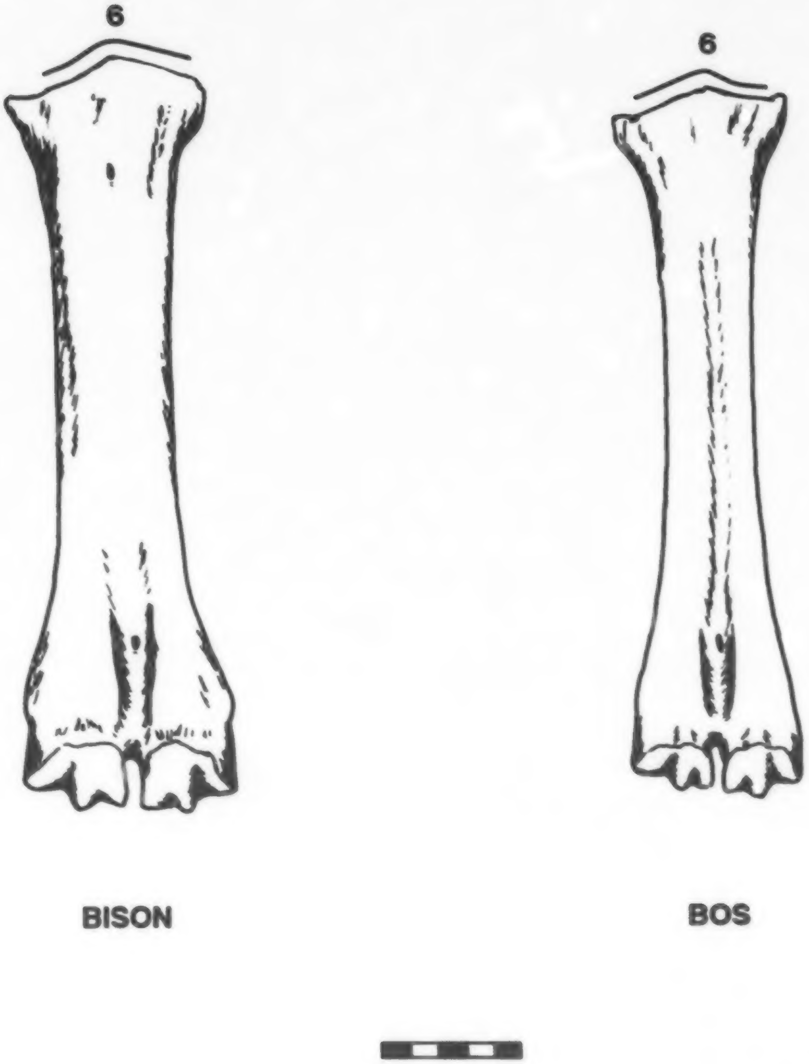
(6)* With the bone held in a vertical position, the margin of the anterior articular surface for the central and fourth tarsal forms a smooth curve or a widely obtuse angle in *Bison*. This margin has a sharp step or break in *Bos*.

success rate for *Bison*	16/24 = 66.67%
success rate for *Bos*	**4/5 = 80.00%

Character #6: margin of anterior articular surface	Aspect 1	Aspect 2	Aspect 3
	smooth curve	sharp break	intermediate
No. of *Bison*	16/24	4/24	4/24
No. of *Bos*	0/5	4/5	1/5
Preference Factor *Bison*	10.05	0.22	0.68
Preference Factor *Bos*	0.10	4.46	1.46

* Character taken from Olsen (1960)

** Note that *Bos* sample size is very small.



BISON

BOS

Figure 96. Metatarsal 3+4, Dorsal View

APPENDIX 1

A Preference Factor Approach to Distinguishing *Bos taurus* from *Bison bison*

General

There is considerable practical difficulty in distinguishing between partial skeletal remains of the two species, *Bos taurus* and *Bison bison*. Through observation of a series of known specimens, we have identified certain 'characters' which tend to differ between the two species. Associated with a character are two or more 'aspects' or 'classes' into which a specimen may fall. For example, a character might be 'the shape of the lateral condyle of the distal humerus'. The aspects might be 'concave', 'flat', and 'convex'.

The question naturally arises as to a quantitative means of expressing the value of a given character/aspect combination in differentiating between the two species and of combining the reults of observations of several characters. One approach, based on the statistical Maximum Likelihood concept, is discussed below.

Caution

Any specimen found is what it was (a denial of physical transmogrification). Statements such as "There is a 95% chance that this specimen is a *Bison*" are totally meaningless. The most that statistical reasoning can lead to is statements of the form: "If this specimen is a *Bos*, then the probability of encountering the observed character/aspect frequencies is considerably less than it would be if this were a *Bison*".

Assumptions

In order to use the maximum likelihood model, we had to make certain assumptions about the known specimens that we observed, as well as about a hypothetical archaeological specimen requiring identification. These assumptions are:

1). The *Bos* and *Bison* specimens we have used in deriving character/aspect frequencies are equivalent to a random selection from all *Bos*, or *Bison*, as applicable.

2). The archaeological specimen is equivalent to a random selection of one individual from its true species.

3). For a given character with *n* possible aspects, a *Bos* or *Bison* selected at random has probabilities

$\{P_1, P_2, \ldots, P_n\}$ *Bison*

$\{Q_1, Q_2, \ldots, Q_n\}$ *Bos*

of exhibiting each of the possible aspects. These P's and Q's are unknown and could be only approximately calculated from the examined specimens due to the small sample sizes involved. Indeed, the preference factors to be developed do not make any explicit assumption as to the values of the P's and Q's.

4). Characters are statistically independent for both *Bos* and *Bison*; that is to say that the observance of a particular aspect for character A yields no additional information as to the aspect for character B.

The Maximum Likelihood Concept

Suppose that the archaeological specimen is really from a *Bison* and, for simplicity, consider only one character with *n* possible aspects. Then a rather complicated expression

$$L_{Bison}(P_1, P_2, \ldots, P_n; Q_1, Q_2, \ldots, Q_n)$$

can be written for the probability of occurrence of the observed frequencies in both the known specimens we scored and in the unknown specimen. Similarly, if it be assumed that the archaeological specimen is from a *Bos*, we can write a similar expression

$$L_{Bos}(P_1, P_2, \ldots, P_n; Q_1, Q_2, \ldots, Q_n)$$

for the probability of occurrence of all results observed for this character.

If we knew the values of the P's and Q's, we could calculate L_{Bison} and L_{Bos} and express them as a ratio. If for example we found that:

$$L_{Bison} / L_{Bos} = 20$$

we could say that the observed results would be twenty times more likely if this were a *Bison* than if it were a *Bos*. It is not really correct to say "the specimen is 20 times more likely to be a *Bison* than a *Bos*", but this does provide a convenient verbal shorthand for expressing a more exact, albeit much wordier, statement.

Since we do not know the P's and Q's, we cannot calculate $\mathrm{L}_{\text{Bison}}$ and L_{Bos} directly. We can, however, calculate L_{Bison} and L_{Bos} where:

L_{Bison} = maximum value of $\mathrm{L}_{\text{Bison}}$ for all conceivable P's and Q's

with a similar definition for L_{Bos}

The underlying assumption in the maximum likelihood is that the observed statistics are more likely to be likely than eccentric. If this assumption is true, then we should have $\mathrm{L}_{\text{Bison}} \sim L_{\text{Bison}}$ and $\mathrm{L}_{\text{Bos}} \sim L_{\text{Bos}}$

If, on the contrary, the specimens we examined were very statistically biased for the character in question, or if the archaeological specimen were very atypical, there is just nothing statistics can do about it.

To spare the reader a considerable amount of algebra, a little calculus, and any further reference to the multinomial distribution, it turns out that, for a given character and aspect *j* (detected on the archaeological specimen)

$$\mathrm{R}_j = L_{\text{Bison}} / L_{\text{Bos}} = \mathrm{N}_j / \mathrm{D}_j$$

where

$$\mathrm{N}_j = ((\mathrm{B}_j + 1)^{(\mathrm{B}_j + 1)} . \mathrm{B}^{\mathrm{B}}) / (\mathrm{B}_j^{\mathrm{B}_j} . (\mathrm{B} + 1)^{(\mathrm{B} + 1)})$$

$$\mathrm{D}_j = ((\mathrm{C}_j + 1)^{(\mathrm{C}_j + 1)} . \mathrm{C}^{\mathrm{C}}) / (\mathrm{C}_j^{\mathrm{C}_j} . (\mathrm{C} + 1)^{(\mathrm{C} + 1)})$$

and

B_j = number of *Bison* in our sample with aspect j

C_j = number of *Bos* in our sample with aspect j

B = number of *Bison* in our sample scored for the given character

C = number of *Bos* in our sample scored for the given character

Observations:

1). R_j depends on both the character and the aspect j of the archaeological specimen. One aspect of a character may convey little information whereas another might be of great help in differentiating *Bos* from *Bison*.

2). Very large ($>>1$) or very small ($<<1$) values of R_j indicate a good character/aspect combination for discrimination.

3). If our sample size were very large we would have:

$N_j = B_j / B$ and $D_j = C_j / C$ giving

$R_j = (B_j . C) / (C_j . B)$

but these are not true for small sample sizes.

4. If more than one of the documented characters is observed on the archaeological specimen, the preference factors multiply. Statistically, this is perfectly correct, but if wildly conflicting preference factors are found, a little skepticism is recommended.

APPENDIX 2. METATARSAL CONDYLOID RATIOS

Antero-posterior depth measurements for medial and lateral condyles were determined for individual specimens, then expressed as a ratio and multiplied by 100% as follows:

$$\frac{\text{depth of medial condyle}}{\text{depth of lateral condyle}} \times 100\%$$

This is the percentage difference between the two condyles; for example, a value of 6.31 means that the medial condyle is 6.31% larger than the lateral condyle.

Although we observed differences in these ratios between the right and left metatarsals of the same individual, we felt that this was outweighed by differences between the two species; i.e. that the ratios fell into two distinct classes, one for the *Bos* specimens and another for *Bison*.

The Student t-test was used to test the significance of the difference between the *Bos* sample mean and the *Bison* sample mean. Measurements from the right metatarsal were used. The null hypothesis was that the two samples could have been drawn from the same population.

$$H_0 : \mu_x - \mu_y = 0$$
$$H_1 : \mu_x - \mu_y = 0$$

$$t = \frac{(\bar{x} - \bar{y}) - (\mu_x - \mu_y)}{\sqrt{\left(\frac{N_x s_x^2 + N_y s_y^2}{N_x + N_y - 2}\right)\left(\frac{1}{N_x} + \frac{1}{N_y}\right)}}$$

In our study

$N_x = 6$ $\quad$ $N_y = 17$
$\bar{x} = 1.795$ $\quad$ $\bar{y} = 5.4606$
$s_x^2 = 0.48211$ $\quad$ $s_y^2 = 1.50946$

$$t = \frac{(1.795 - 5.4606) - 0}{\sqrt{\left[\frac{(6)(0.48211) + (17)(1.50946)}{6 + 17 - 2}\right]\left[\frac{1}{6} + \frac{1}{17}\right]}}$$

$t = -6.62005$

$\text{D.f.} = N_x + N_y - 2 = 21$

$P << 0.005$

Therefore, reject H_0 and conclude that there is a significant difference in the means of the ratios of the *Bos* sample and the *Bison* sample.

APPENDIX 3. SPECIMENS EXAMINED FOR THIS STUDY

Genus & Species	Subspecies or Breed	Sex	Age	Source	Catalogue Number
Bos taurus	Holstein	F	7 yrs.	CMN**	NMC 40163
Bos taurus	dairy cow	F	(1)*	CMN	Z-130
Bos taurus	Holstein	F	1 yr.	CMN	NMC 40154
Bos taurus			(1)	CMN	NMC 37062
Bos taurus	Holstein	F	15 yrs.	CMN	NMC 75122
Bos taurus			(4)	CMN	uncatalogued
Bos taurus			(4)	CMN	uncatalogued
Bos taurus			(1)	FOL	FA 348-1
Bos taurus	Ayrshire	M	(1)	Smith	USNM 290610
Bos taurus	Shorthorn	M	(1)	Smith	USNM 269405
Bos taurus	Longhorn	M	(1)	Smith	USNM 277262
Bos taurus			(3)	Smith	USNM 14504
Bos taurus	Longhorn	M	(1)	Smith	USNM 155628
Bos taurus	Africander	M	(1)	Smith	USNM 270618
Bos taurus	Holstein	M	2.5-3 yrs.	CMN	NMC 75234
Bos taurus	Holstein	F	5.5 mos.	CMN	AR 332
Bison bison	*bison*	M	(2)	Smith	USNM 22375
Bison bison		F	(1)	Smith	USNM 197705
Bison bison	*bison*	M		Smith	USNM 63363
Bison bison			(4)	CMN	AR 348
Bison bison	*athabascae*	F	6 yrs.	CMN	NMC 39876
Bison bison	*athabascae*	M	6 yrs.	CMN	NMC 39875
Bison bison	*bison*	M	(1)	ROM	22-10-2-1
Bison bison	*bison*	M	(1)	ROM	33-4-6-7
Bison bison	*bison*		(1)	ROM	27961
Bison bison		F	3 yrs.	FOL	FA 347-2
Bison bison	cf. *athabascae*	M	(1)	CMN	NMC 32628
Bison bison	cf. *bison*		(1)	CMN	NMC 75120
Bison bison	cf. *bison*		(1)	CMN	NMC 75121
Bison bison		M	(1)	CMN	NMC 5552
Bison bison	*athabascae*	M		CMN	72-44
Bison bison	*bison*	M	(1)	CMN	NMC 45416
Bison bison	*athabascae*	M	(3)	CMN	1979-61 #1
Bison bison	*athabascae*	M	(3)	CMN	1979-61 #2
Bison bison	*athabascae*	M	(3)	CMN	1979-61 #4
Bison bison	*athabascae*	M	(4)	CMN	1979-61 #5
Bison bison	*athabascae*	M	(1)	CMN	1979-61 #6
Bison bison	*athabascae*	M	(1)	CMN	1979-61 #7
Bison bison	*athabascae*	M	(3)	CMN	1979-61 #8
Bison bison	*athabascae*	M	(2)	CMN	1979-61 #9
Bison bison	*athabascae*	M	(1)	CMN	1979-61 #10
Bison bison	*athabascae*	M	(1)	CMN	1979-61 #11
Bison bison		M	(1)	CMN	NMC 6008
Bison bison		M	(1)	CMN	NMC 6010

* EXPLANATION OF AGE CLASSES

(1) all epiphyses completely fused

(2) vertebral epiphyses not completely fused; all other epiphyses fused

(3) epiphyses of most long bones fused, but fusion incomplete on some long bones

(4) epiphyses of most long bones unfused

** SOURCES FOR SPECIMENS

CMN - Canadian Museum of Nature

FOL - Faunal Osteology Lab, Dept. of Anthropology, University of Toronto

ROM - Royal Ontario Museum

Smith - Smithsonian Institution

APPENDIX 4

CATALOGUE NUMBERS OF SPECIMENS USED IN ILLUSTRATIONS

Most of the illustrations were drawn using *Bos taurus* NMC 40163 and *Bison bison* NMC 75120. The exceptions are as follows:

Bos taurus Z-130 was used for Figs. 2, 11, 12, 38, 54, 55, 56, 57, 58, 59, 60, 66, 69, 72, 76, 77, 78, 79, 89, 90, 91, 92, 93

Bos taurus NMC 75122 was used for Figs. 23, 28, 30, 31, 32, 33, 47.

Bos taurus 75234 was used for Figs. 3, 39, 80, 81, and 82.

Bison bison NMC 75121 was used for Figs. 8, 14, 15, 28, 29, 30, 38, 39, 46, 52, 53, 65, 66, 67, 78, 94, 95, and 96.

Bison bison NMC 45416 was used for Figs. 2, 3, 9, 10, 11, 18, 19, 25, 26, 27, 34, 35, 36, 37, 74, 75, 85, 86, 87, and 88.

Bison bison AR 348 was used for Fig. 13.

Recent *Syllogeus* Titles / Titres récents dans la collection *Syllogeus*

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No. 61	Noble, W.J., T. Ahti, G.F. Otto and I.M. Brodo (1987) A SECOND CHECKLIST AND BIBLIOGRAPHY OF THE LICHENS AND ALLIED FUNGI OF BRITISH COLUMBIA. 95 p.
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